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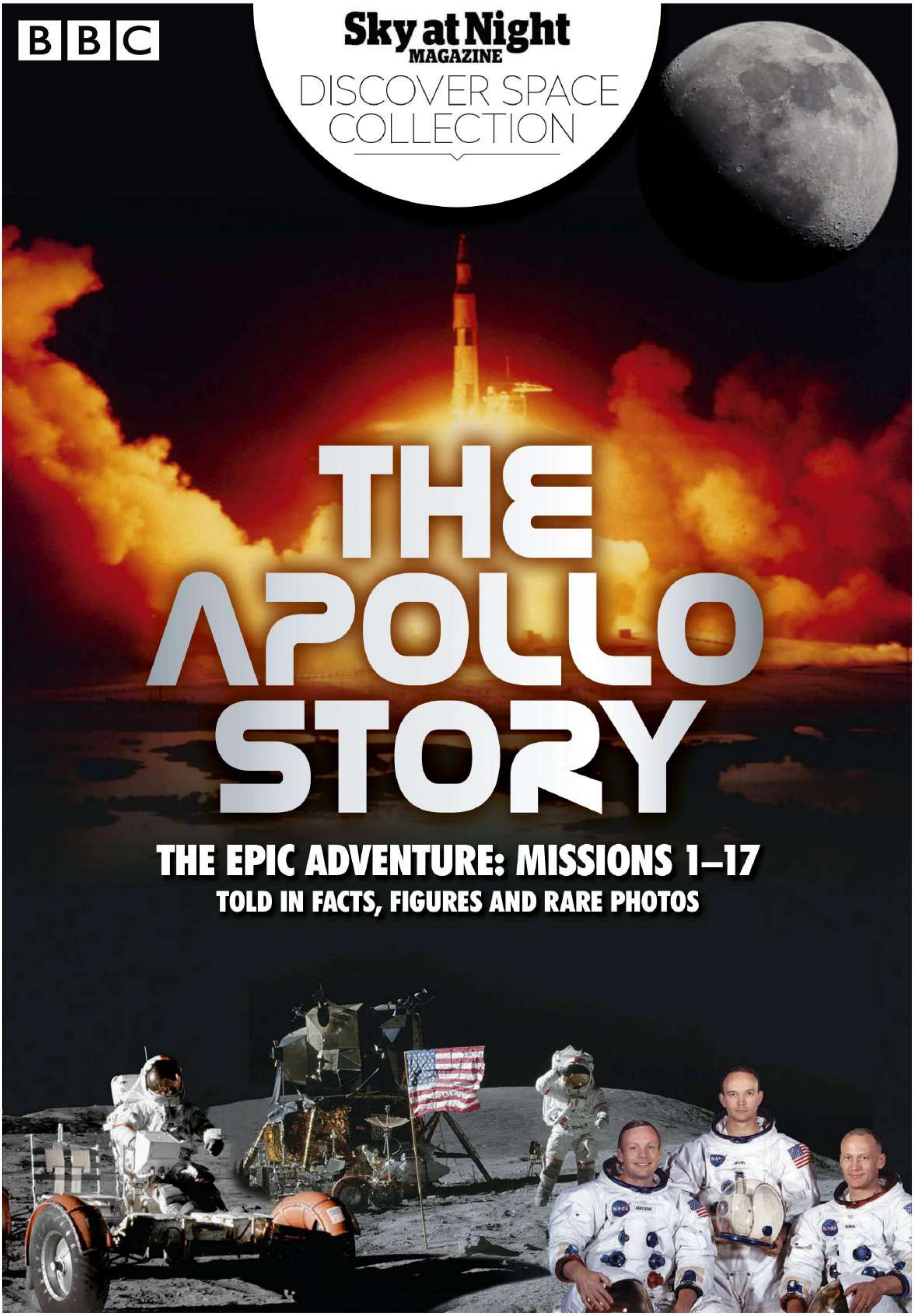

THE APOLLO STORY

THE EPIC ADVENTURE: MISSIONS 1–17

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SPECIAL EDITION

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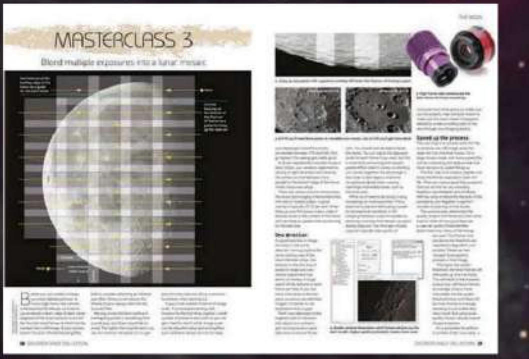

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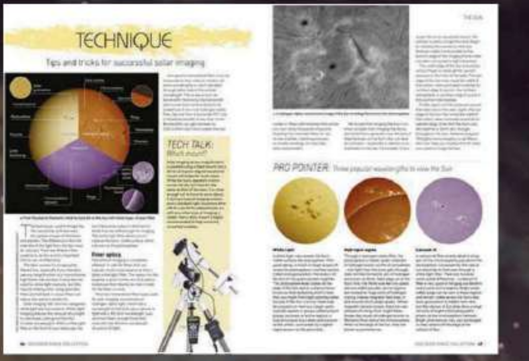

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WELCOME

The Apollo programme stands as humankind's greatest achievement. With Neil Armstrong's historic first step on the Moon's Sea of Tranquility, our species knew that it was not bound to the planet on which it had evolved, and could truly reach for the stars. To prove it was not chance, six more lunar landings delivered a total of 12 explorers over 380,000km across deep space to Earth's satellite.

In this special edition to mark the 50th anniversary of that extraordinary first landing, you will meet these moonwalkers, as well as all the other astronauts who accepted the bold challenge of the Apollo project. The project was not without its tragedy – the first manned mission saw three astronauts die while still on the launch pad – or its tension, when Apollo 13 experienced an explosion mid-journey. But in nine short years half a century ago, the USA's remarkable achievements proved that humanity could become a spacefaring species.

That it did so was thanks to the curiosity, knowledge and passion of hundreds of thousands of people, spurred on to create a golden age of space exploration. Those scientists, engineers, technicians and administrators are pictured throughout these pages, in spellbinding images that remind us how momentous their task was.

Fifty years on from the epic adventure of Apollo, it is tempting to look on the project as a futile folly. But we must remember that during those five decades we have been busy: humans have now sent spacecraft to every planet in the Solar System and, indeed, have reached interstellar space. We are reducing the cost of spaceflight and have lived in orbit on the International Space Station continuously for nearly two decades. Steeled by the spirit of Apollo, what we now know makes us ready to set foot on other worlds once again.

Chris

Chris Bramley
Editor, *BBC Sky at Night Magazine*

BACK COVER IMAGE:
Harrison Schmitt, the last manned
Moon mission, December 1972

Spectators, including the King and Queen of Belgium, gather to watch Apollo 10 lift-off

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to Neil Armstrong

BEFORE APOLLO

In the post-war era, the USA and USSR – two superpowers locked in a battle for supremacy – turned their eyes to space

In the middle of the 20th century, two brilliant engineers triggered a rocket race between the Soviet Union and the USA. Each man had known the worst cruelties of his times. One had narrowly avoided death in a labour camp, while the other was arguably partially responsible for creating one. The machines they created threatened devastation at the same time as they promised the stars.

In 1938, aircraft engineer Sergei Korolev was developing simple rockets at an army laboratory in Moscow when he fell victim to one of Joseph Stalin's terror purges. He was tortured and imprisoned in a Siberian gulag. Three years later, close to death, he was recalled to Moscow. Hitler's armies had invaded and Stalin needed engineers. Then, in 1945, Korolev was sent into Germany to recover and study the remnants of German V-2s, rockets that were similar to those he had dreamed of building.

Fuelled by war

Wernher von Braun is the only 'rocket scientist' whose name is familiar to many. Born into an aristocratic German family, he was obsessed by space. When the Nazis came to power, he persuaded Hitler that rockets would make effective weapons. He developed what became known as the V-2 'Vengeance' rocket at Peenemünde, on the Baltic coast. In 1943, a hellish underground factory was built at Nordhausen in central Germany, where starving slave prisoners assembled von Braun's rockets under SS command.

> “The R-7's primary function was to launch nuclear bombs, but Korolev knew it could carry lighter payloads into space”

As the Nazi regime crumbled, British, American and Soviet intelligence teams scoured the devastated German landscape, hunting for any remains of von Braun's work. It was clear that the V-2's descendants, armed with nuclear warheads, could reshape the balance of power. Von Braun surrendered to American forces, staging an escape for himself and many colleagues under the noses of SS death squads, who were executing 'disloyal' Germans.

There followed a decade of unambitious V-2 tests in the White Sands desert of New Mexico. Von Braun was frustrated by the American government's lack of interest. In the mid-1950s, Walt Disney encouraged him to present his ideas for peaceful space exploration on TV, which helped improve his reputation.

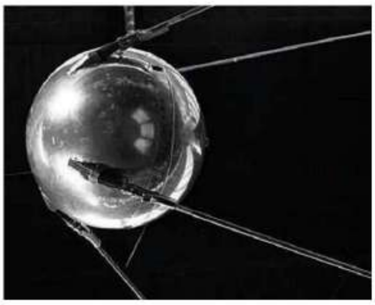
Meanwhile, Korolev set to work on Raketa-7 (R-7), the first intercontinental missile, along with a secret launch complex at Baikonur in Kazakhstan, at that time part of the Soviet Union. The R-7's primary function was to launch nuclear bombs at the USA, but Korolev knew it could also carry lighter payloads into space. He bluffed sceptical Red Army generals into granting him the use of one R-7 for a satellite launch. On 4 October 1957, he sent Sputnik into orbit.

The Soviet leader, Nikita Khrushchev, was delighted by America's shocked reaction. He urged Korolev to launch something else as fast as possible. Sputnik II flew a month later, this time carrying a live passenger, a dog

S-IV
UNITED
UNITED

RIGHT Von Braun (centre) explains the new Saturn launch system to President Kennedy

ABOVE Walt Disney (left) and Wernher von Braun discuss the possibility of space exploration

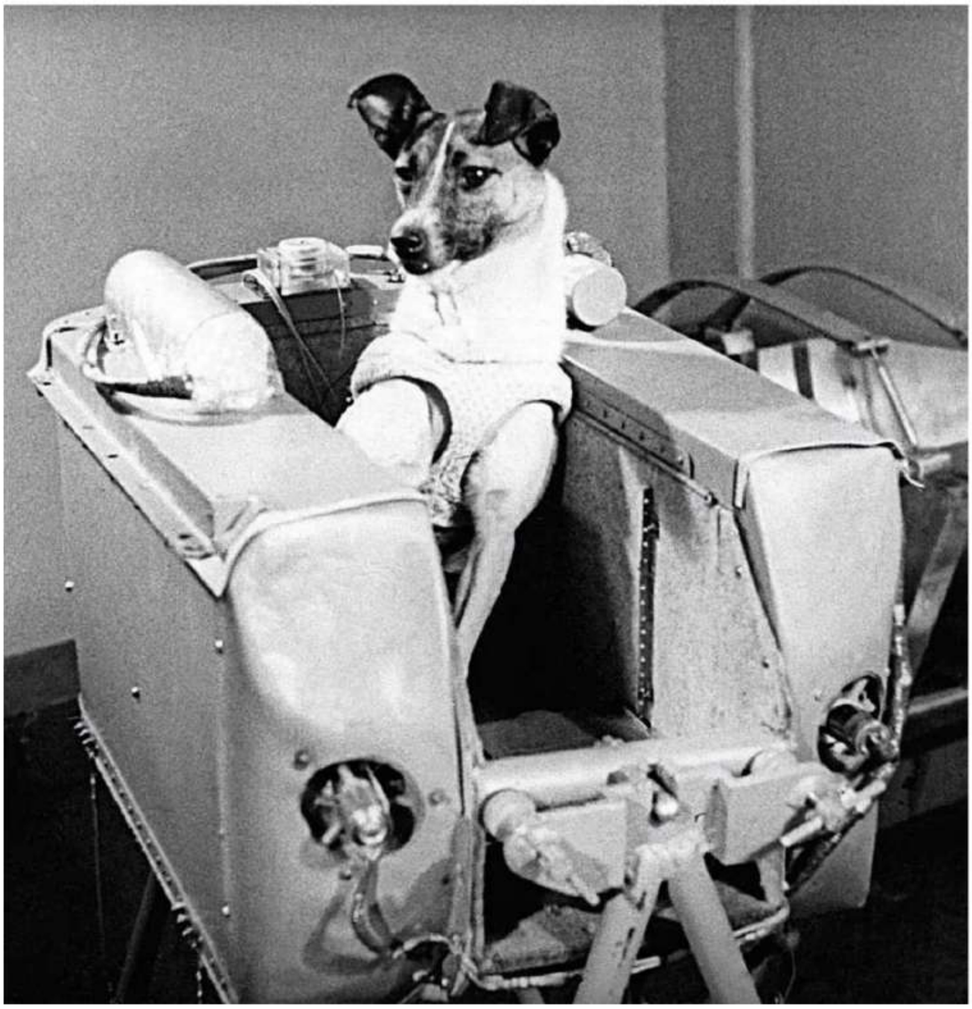


ABOVE Soviet satellite Sputnik launches on 4 October 1957

named Laika. Korolev's ambition was clear: he wanted to launch a human into space. He promised the Red Army a new satellite for snooping on the West, but explained that first he would have to enlist a pilot with excellent eyesight to look out of the satellite's window and check on what the spy cameras might see. The generals believed him and in October 1959 a squad of 'cosmonauts' was formed.

The Space Race begins

US President Dwight D Eisenhower was reluctant to spend money on rockets. He feared the influence of a new 'military-industrial complex'. Only when an underfunded Navy satellite launcher, the Vanguard, blew up on the pad was von Braun summoned, at last, to rescue America's faltering space effort. His team launched a satellite, Explorer 1, on an adapted ►



ABOVE Laika the dog sits in Sputnik 2. Sadly, she died shortly after launch

LEFT Explorer 1, launched in January 1958, is the first satellite to carry scientific equipment

On 12 April 1961, Soviet cosmonaut Yuri Gagarin is the first man to go into space

▶ short-range Jupiter-C missile, renamed 'Juno' to disguise its military origins. The rocket was based on the US Army's Redstone missile, and this in turn was derived from V-2 technology, right down to adjustable carbon vanes for steering the exhaust.

The National Aeronautics and Space Administration (NASA) was created in July 1958 and given just enough cash to develop a small manned space capsule, Mercury. Eisenhower, still harbouring doubts about space exploration, insisted that it should be a civilian project.

Another setback

Von Braun and his colleagues, under the leadership of NASA's first chief administrator Keith Glennan, and his successor James Webb, struggled to catch up with the USSR. On 12 April 1961, the USA was disturbed by another success for Korolev's R-7, when Yuri Gagarin orbited Earth aboard a Vostok capsule and came home safely. John F Kennedy, America's newly elected president, was desperate to respond. "If somebody can just tell me how to catch up. Let's find somebody, anybody. I don't care if it's the janitor over there, if he knows how."

The launch of Apollo

Five days later, a CIA-backed squad of Cuban exiles tried to dislodge Fidel Castro's Communist regime. The attempt was a fiasco and Kennedy turned to space, hoping to restore his prestige. On 20 April, he asked Vice President Lyndon Johnson, an ardent campaigner for space superiority, "Do we have a chance of beating the Soviets by putting a laboratory in space, or by a trip around the Moon, or by a rocket to land on the Moon? Is there any other space program which promises dramatic results in which we could win?".

The final decision hinged on NASA getting their manned programme off the ground. Alan Shepard was launched into space in a Mercury capsule on 5 May 1961. His flight lasted just 15 minutes, but it was enough to boost Kennedy's confidence. In a historic speech on 25 May 1961, he told Congress: "I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon." Project Apollo was initiated because America's first astronaut was launched 23 days later than the Soviet's first cosmonaut. If it hadn't been for those three weeks, Kennedy might never have reached for the Moon. ❺

> “ NASA was created in July 1958 and given just enough cash to develop a small manned space capsule, Mercury ”

ABOVE Before NASA, the National Advisory Committee for Aeronautics (NACA) led the way in space research

ABOVE Mission complete: Shepard is hauled aboard the recovery helicopter

RIGHT Shepard receives the NASA Distinguished Service Medal from President John F Kennedy

"I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to Earth." President John F Kennedy, 25 May 1961

APOLLO 1-6

THE EARLY APOLLO MISSIONS ARE FILLED WITH DRAMA AND TRAGEDY

MISSION FACTS

OBJECTIVE: To test the Command Module, the Lunar Module and the rockets that would propel the spacecraft into space – the Saturn IB and later the Saturn V. When disaster strikes Apollo 1, NASA is forced to postpone manned flight testing.

DATE: 26 February 1966 to 4 April 1968

UNITED STATES

The arrival of part of the Saturn IB, which was intended to launch Apollo 1

The numbers of most Apollo missions are relatively well known. Apollo 7 was the first successful manned launch, Apollo 8 made the first circumlunar voyage, Apollo 11 achieved the first touchdown, Apollo 13's crew survived an explosion, and Apollo 17 was the last mission. But what about Apollo 1–6?

The first items of Apollo hardware flew into orbit in February 1966 for an unmanned test of the Command Module engine and the capsule's heat shield. The launch vehicle was a Saturn 1B – an interim rocket based on eight Redstone fuel tanks and powerful enough to lift Apollo off the Earth, even if the Moon was beyond its reach. The Command Module engine stuttered and the capsule's re-entry was imperfect, but it came back in one piece. The mission was designated Apollo-Saturn 201, or AS-201. Two more unmanned Saturn 1B flights were launched during 1966, testing various systems, including the ability to restart the upper stage's hydrogen-fuelled engine in space.

The mighty Saturn V made its launch debut on 9 November 1967. The flight was labelled Apollo-Saturn 501 (AS-501), and was sometimes referred to as Apollo 4. All seemed to go well, but a second unmanned launch in April 1968 (AS-502, or Apollo 6) threw NASA into a tailspin. The Saturn experienced violent vibrations and multiple engine failures. The upper section, with dummy Apollo hardware, was damaged. This unhappy launch occurred at a time when NASA was still in shock from an appalling tragedy.

> “Apollo 6's unhappy launch occurred at a time when NASA was still in shock from an appalling tragedy”

Apollo mission AS-204 was to have been the first manned test of the Command Module. On 27 January 1967, astronauts Gus Grissom, Ed White and Roger Chaffee climbed into their capsule for a routine countdown rehearsal. The Saturn was not even fuelled. Nevertheless, an explosion occurred.

As astronaut Grissom climbed through the hatch, he complained that the capsule's interior ▶▶

MEET THE CREW

COMMAND PILOT
VIRGIL 'GUS' GRISSOM

Born in Indiana on 3 April 1926, Grissom joined NASA in 1959 as one of the original Mercury 7 astronauts. His flight with Gemini 3 made him the first NASA astronaut to fly in space twice. At the time of his death, Grissom had achieved the rank of Lieutenant Colonel and had logged a total of 4,600 hours of flying time.

BACKUP CREW
COMMANDER
Walter Schirra

SENIOR PILOT
ED WHITE

White followed his father's footsteps into the Air Force before gaining a Master's degree in aeronautical engineering and joining NASA in 1962. White was born on 14 November 1930 in Texas and became the first American to walk in space in the 1965 Gemini 4 mission, describing the order to return to the capsule as "the saddest moment of my life."

BACKUP CREW
COMMAND MODULE PILOT
Donn Eisele

PILOT
ROGER CHAFFEE

Chaffee was born on 15 February 1935 in Michigan and joined NASA in 1964 as a member of Astronaut Group 3. While he never got a seat on a Gemini mission, Chaffee was paired with fellow Apollo 1 pilot 'Gus' Grissom to fly chase planes that would follow and film the launch of an unmanned Saturn 1B rocket.

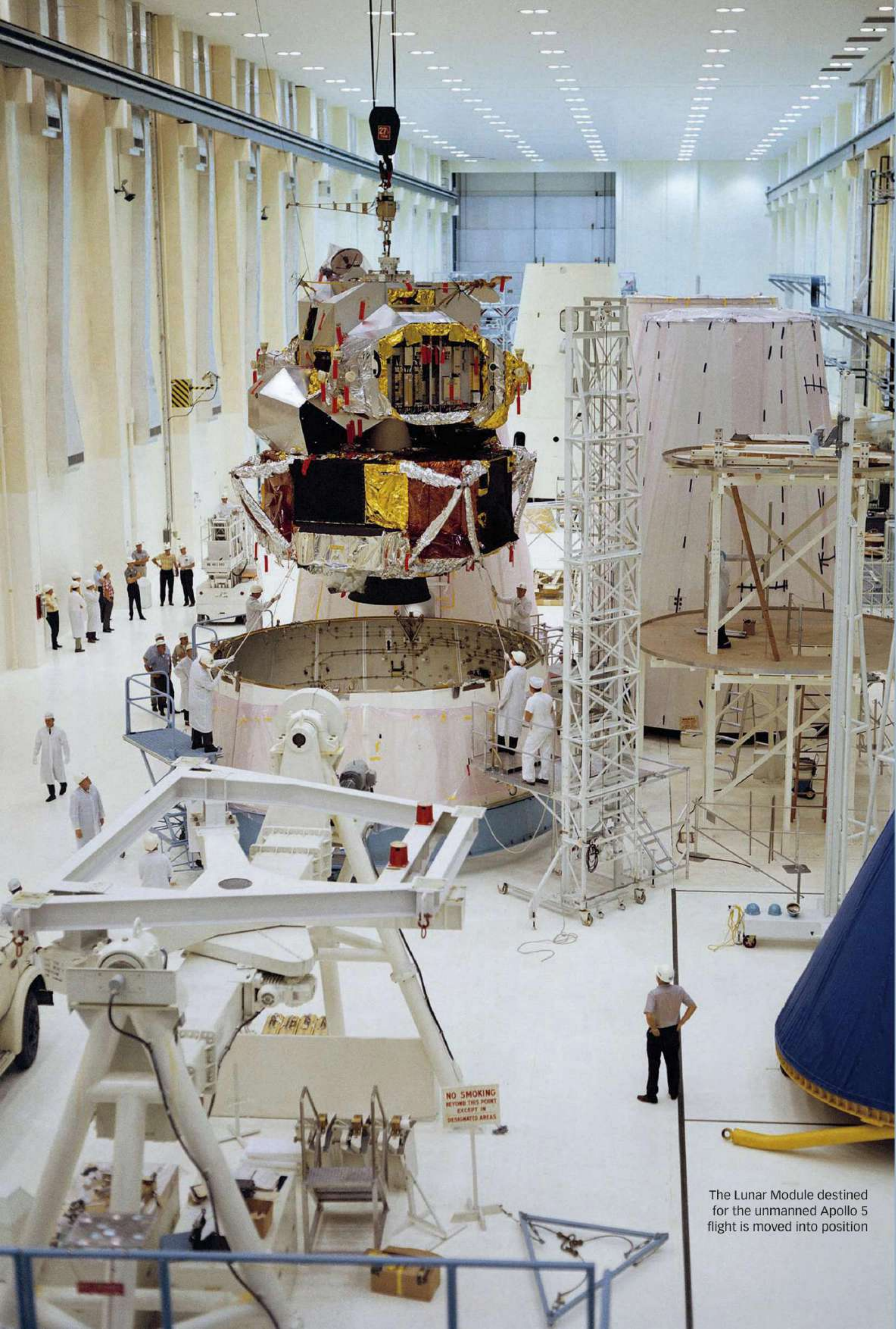
BACKUP CREW
LUNAR MODULE PILOT
Walter Cunningham

RIGHT The Apollo 1 crew practise getting out of the Command Module and into life rafts

ABOVE Apollo 1, before it is put on the Saturn IB rocket for launching

ABOVE (l–r) Chaffee, White and Grissom train in the Command Module

LEFT Apollo 1's fire-ravaged Command Module is lowered from the gantry


NO SMOKING
BEYOND THIS POINT
EXCEPT IN
DESIGNATED AREAS

The Lunar Module destined for the unmanned Apollo 5 flight is moved into position

MISSION TIMELINE

26 February 1966 – AS-201

The first unmanned, suborbital test flight of the Saturn IB rocket and the Apollo Command Module. The Service Module engine only works properly for 80 seconds and the electrical system fails, causing the Command Module to lose control during re-entry. The flight lasts 37 minutes.

5 July 1966 – AS-203

An unmanned flight of just the Saturn IB rocket. The mission's main intention is to test the rocket for future Apollo missions. It achieves this – and other goals – before suffering an explosion on its fourth orbit during further experiments.

25 August 1966 – AS-202

This is meant to be the second test flight, but a delay with the Command Module results in the launch being pushed back. It is the second unmanned test flight of the Saturn IB and the Apollo Command Module. The rocket is launched higher and the flight lasts over twice as long as AS-201. After this success the next step is to take men into orbit.

27 January 1967 – AS-204/APOLLO 1

As the first manned flight of the Apollo programme, expectations are high. However, tragedy strikes during a routine launch pad test when a fire starts in the capsule, killing the crew.

9 November 1967 – APOLLO 4

This is the famous Saturn V's first flight. All rocket stages and spacecraft are fully functional on the initial flight, which is a first for NASA. All tests and goals are completed and NASA deems the mission a complete success.

22 January 1968 – APOLLO 5

The first unmanned flight of the Apollo Lunar Module, testing its descent and ascent engine systems in space. NASA insists the mission is a success, although the onboard computer aborts a planned 39-second descent engine burn after just four seconds.

4 April 1968 – APOLLO 6

The final unmanned Apollo test flight's objective, among others, is to show that the Command Module's heat shield can cope with a lunar reentry. Despite problems with severe vibration rupturing igniter fuel lines, NASA is confident enough to declare Saturn V man-rated. This last unmanned flight lasts nine hours, 57 minutes.

Schirra (left) and Cunningham, who will fly on Apollo 7, are present for the unmanned launch of Apollo 5 in January 1968

> “The mood was tense as pad technicians locked Apollo's heavy hatch into place, sealing the crew inside”

▶▶ smelled of sour milk. Then the radio system glitched, causing a frustrated Grissom to shout, “How are we going to get to the Moon if we can't even talk between two or three buildings?”. The mood was tense as pad technicians locked Apollo's heavy hatch into place, sealing the crew inside.

The tragedy

They were five hours into the test when a garbled voice, possibly Grissom's, on the crackling radio link said, “We've got a fire in the cockpit!” A few seconds later, another voice was more urgent. “Hey, we're burning up in here!” There was a scream of pain, then just a hiss of static as the radio went dead.

The pad crew, high atop the launch gantry, tried desperately to get the astronauts out. The smoke was impenetrable and the heat overpowering. It took five minutes to open the hatch. By then, the three astronauts were dead. Manned Apollo missions were put on indefinite hold while NASA was investigated by a congressional inquiry.

NASA had pushed too fast to meet President Kennedy's famous deadline for landing a man on the Moon. Despite everyone's best intentions, a number of fire risks in the Command Module's pure-oxygen environment had been overlooked, including the faulty wiring that most likely started the blaze.

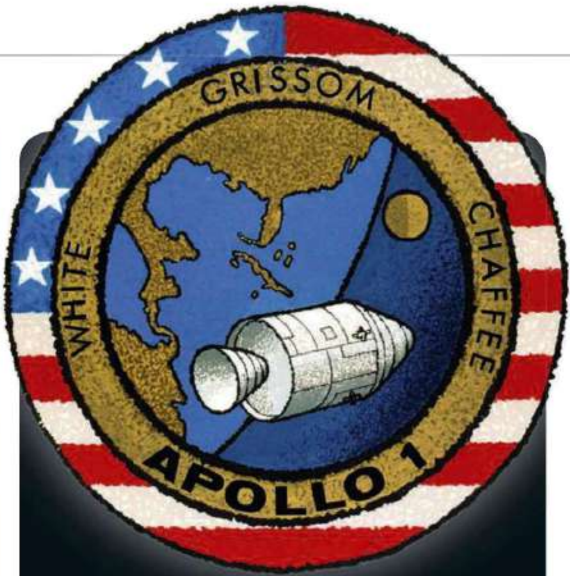
There was immense pressure to scale back or even cancel Apollo in the wake of the fire. President Kennedy was long gone, and his successor, Lyndon Johnson, was preoccupied with the Vietnam War. Many people thought that landing on the Moon was no longer as important as it had seemed back in 1961.

Still in the race

The Apollo capsule was redesigned while NASA worked on fixing the Saturn V. In January 1968, a Saturn 1B lifted off carrying an unmanned Lunar Module for basic tests, on a mission designated Apollo 5. Just three months later, the Saturn V was ready for launch, and the final unmanned mission, Apollo 6, went ahead. Meanwhile, the widows of the three dead astronauts urged that their husbands should be honoured by renaming their doomed mission Apollo 1. This partially explains the strange numbering system for Project Apollo that we know today. ●

RIGHT Apollo 6 lifts off on 4 April 1968. It is the last unmanned test flight

BELOW This image of the Apollo 6 launch was taken from a chase plane

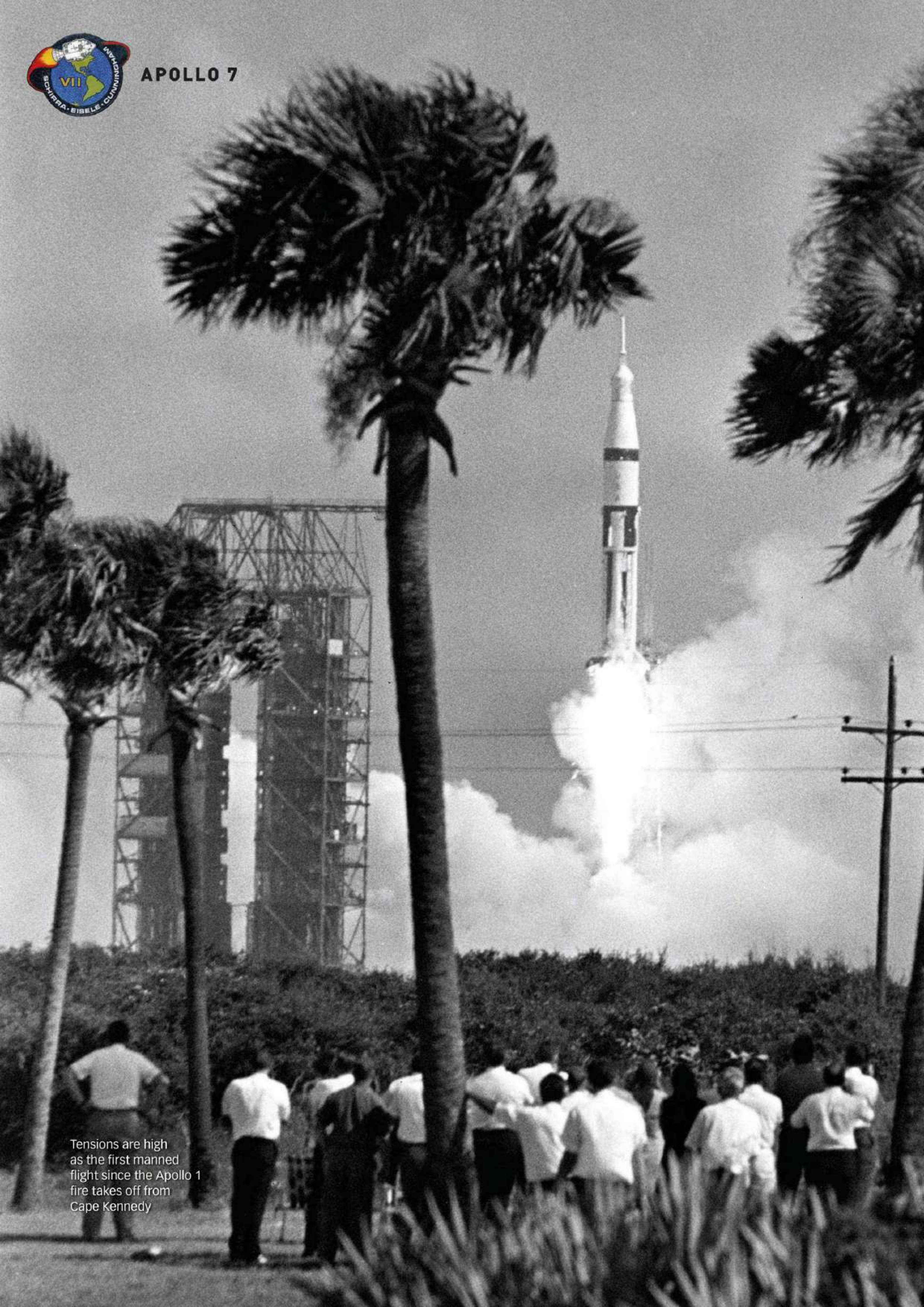


MISSION BADGE

Shrouded in tragedy, the first Apollo patch was devised with the idea that it was going to be the programme's first orbital flight. It was designed entirely by the crew, who were inspired by Gemini 4's famous American flag patch. There were no non-flammable versions of the patches; these came after the disastrous test launch fire that took the lives of all three crew members. Armstrong and Aldrin left the patch on the Moon when they landed in July 1969.

ABOVE Mission Control anxiously monitor the Apollo 6 flight

LEFT The spent Apollo 6 interstage falls away



Tensions are high as the first manned flight since the Apollo 1 fire takes off from Cape Kennedy

11 October 1968

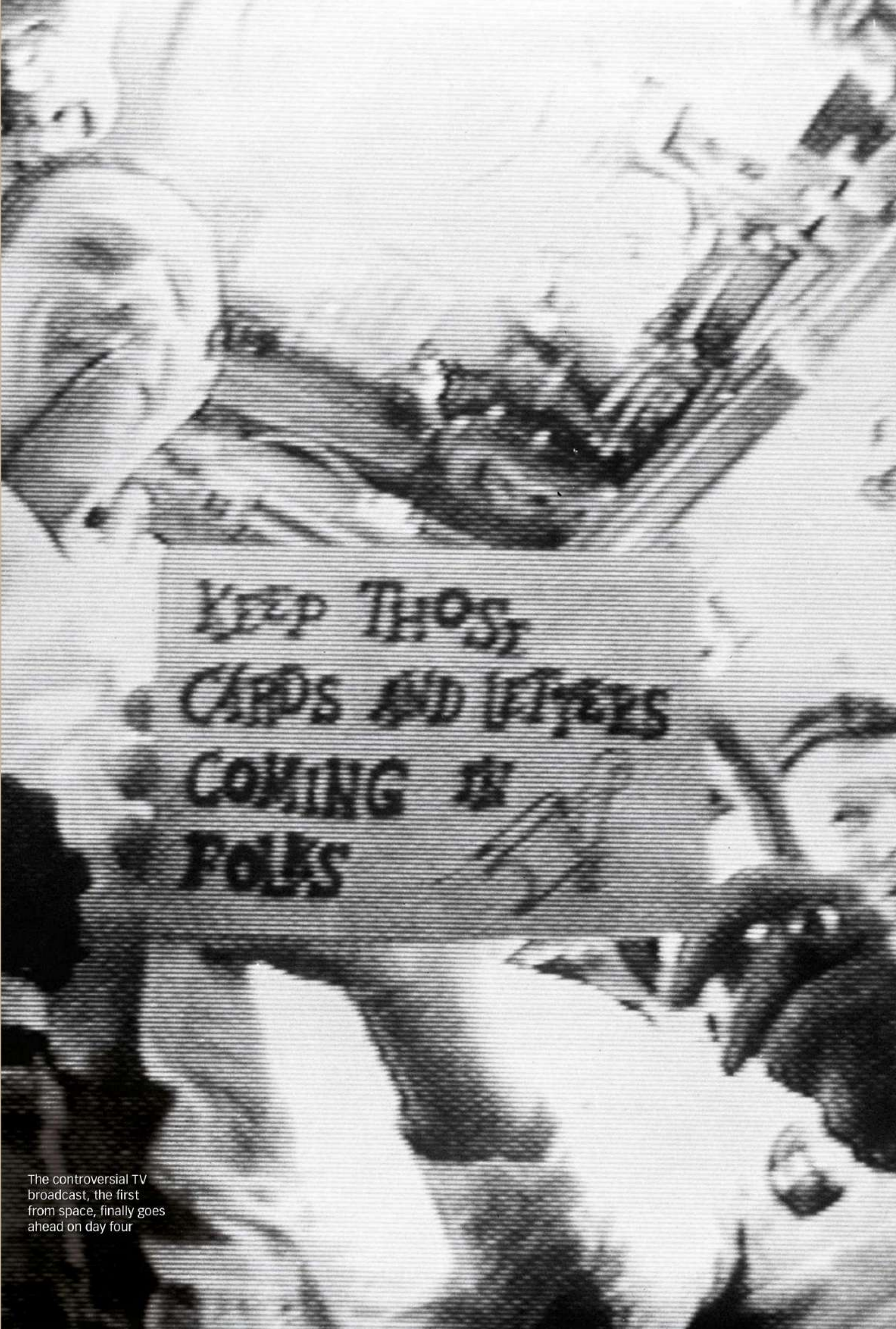
APOLLO 7

APOLLO'S FIRST MANNED MISSION PUTS NASA BACK ON TRACK

MISSION FACTS

OBJECTIVE: To test the Command Module while in Earth's orbit. The crew conducted the first live TV broadcast from an American spacecraft.

DURATION: 10 days, 20 hours, 9 minutes, 3 seconds


KEEP THOSE
CARDS AND LETTERS
COMING IN
FOLKS

The controversial TV broadcast, the first from space, finally goes ahead on day four

In the wake of the Apollo 1 catastrophe, the best way for NASA to regain public trust was to successfully fly a manned spacecraft. At last, on 11 October 1968, Apollo 7 reached Earth orbit with a crew aboard. Donn Eisele, Walter Cunningham and commander Wally Schirra's mission was to prove that the capsule, redesigned after Apollo 1, could function correctly in space. Additionally, there would be a test firing of Saturn IB's second stage, S-IVB, whose job in future missions was to push the combined Apollo capsule and its Lunar Module (LM) out of Earth orbit and towards the Moon.

After a successful rocket burn that pushed Apollo 7 into a higher orbit, the Command Module (CM) disconnected from the S-IVB, turned around and conducted a simulated docking approach. Finally, the CM's engine was fired several times, making sure that it could hold future crews in lunar orbit and boost them out again for the trip back to Earth.

The wrong stuff

Everything worked. Apollo 7 should have been a cause for celebration, but when the crew got home after 11 days in orbit, they were given a roasting by senior officials. None of them flew into space again. Eisele and Cunningham were both making their debuts, but Schirra had flown on Mercury and Gemini capsules, and thought he knew better than anyone else how to run things.

Tensions arose with Mission Control on day one of the flight when Schirra decided to postpone a live television broadcast. "We have a new vehicle up here. TV will be delayed without any further discussion." He had developed a nasty head cold, and Cunningham and Eisele soon caught the same bug. They all became extremely irritable as a result. At one point Schirra complained – on an open microphone link – about a particular hardware test: "I wish you would find out the idiot's name who thought up this test. I want to talk ▶▶

> “When the crew got home after eleven days in orbit, they were given a roasting. None of them flew into space again”

MEET THE CREW

COMMANDER
WALTER SCHIRRA

Schirra was one of the first NASA recruits. Born in New Jersey on 12 March 1923, by 1959 he was an astronaut. With Apollo 7 he became the first person to make three trips into space, having already flown Mercury and Gemini missions. Leaving NASA in 1969, Schirra had a successful business career. He died on 3 May 2007.

BACKUP CREW
COMMANDER
Thomas Stafford

COMMAND MODULE PILOT
DONN EISELE

Born in Columbus, Ohio, on 23 June 1930, Eisele was a USAF test pilot with over 4,200 hours flying time when he joined NASA in 1963. He was backup Command Module pilot for Apollo 10, but left the space programme in July 1972 to become Director of the US Peace Corps in Thailand and, later, a businessman. He died on 2 December 1987, aged 57.

BACKUP CREW
COMMAND MODULE PILOT
John Young

LUNAR MODULE PILOT
WALTER CUNNINGHAM

Ronnie Walter Cunningham – a former scientist – was born in Iowa on 16 March 1932 and joined NASA as the second civilian astronaut in 1963. He left in 1971 to attend Harvard Business School and in 1977 wrote *The All-American Boys*, a memoir of his astronaut days. He is still a public speaker on space exploration.

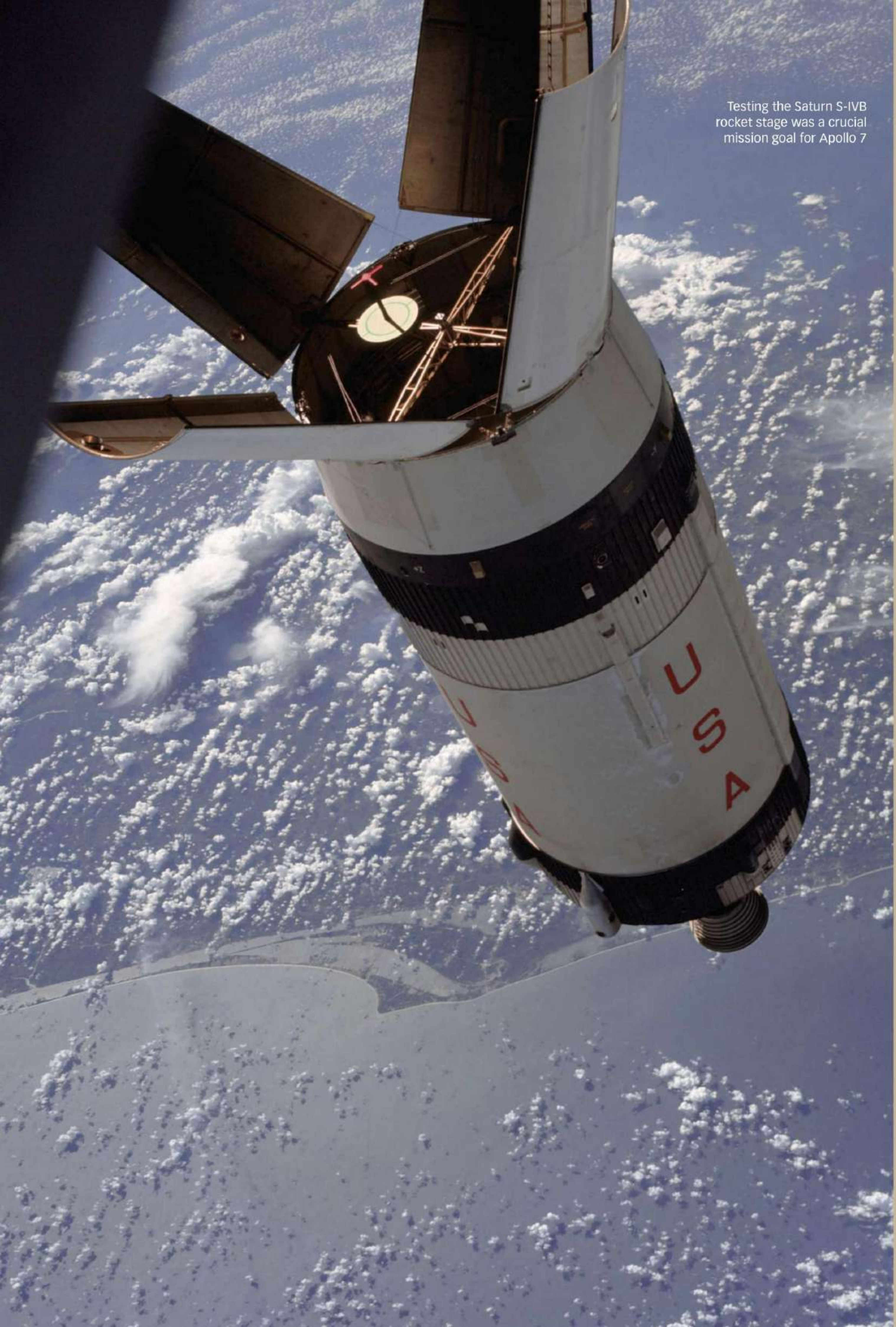
BACKUP CREW
LUNAR MODULE PILOT
Eugene Cernan

RIGHT Saturn IB, carrying Apollo 7, shoots through the air, more than 10,000 metres above the Atlantic Ocean

BELOW Flying 210km over the Earth, Apollo 7 captures high-resolution images, including mighty Mount Everest

ABOVE The Apollo programme afforded revealing new views of Earth

ABOVE The morning sun reflecting off the Atlantic Ocean at the Florida peninsula, captured during the 10-day flight



Testing the Saturn S-IVB rocket stage was a crucial mission goal for Apollo 7

MISSION TIMELINE

11 October 1968
At 15:02 GMT, Apollo 7 lifts off. The Saturn IB, a half-sized variant of the Saturn rocket family, delivers a pleasingly perfect launch.

11 OCTOBER: 2 MINUTES
The first stage drops away and the second stage, the liquid hydrogen-fuelled S-IVB, takes over.

11 OCTOBER: 10 MINUTES
Apollo 7 reaches the first stage of its journey, an interim orbital path at an altitude ranging from 227km to 285km above the Earth.

11 OCTOBER: 2 HOURS, 30 MINUTES
The remaining hydrogen fuel and oxygen inside the S-IVB are vented into space, pushing Apollo 7 into a slightly higher orbit, and testing the S-IVB's ability to re-light its engine.

11 OCTOBER: 2 HOURS, 55 MINUTES
The Command Module (CM) separates from the S-IVB, turns around and performs a simulated Lunar Module (LM) docking/extraction manoeuvre.

12 OCTOBER: 26 HOURS, 24 MINUTES
Early on day two, the Command Module (CM) fires its engine for the first of eight burns during the mission. Burn durations range from half a second to 67 seconds.

12 OCTOBER
Apollo 7 and the S-IVB drift about 120km apart. Apollo begins a series of rendezvous manoeuvres, practising how to locate and approach a LM's ascent stage after it has climbed back up from the lunar surface.

14 OCTOBER
After a few days of tension, the first live TV broadcast from a manned American spacecraft is finally shown. All previous annoyances are forgotten for the brief clips from the astronauts.

22 OCTOBER: 259 HOURS, 35 MINUTES
Nearly 11 days into the mission, the CM separates from its service module and begins its descent for re-entry, after having completed 163 orbits of the Earth. It splashes down 25 minutes later in the Atlantic, 370km southwest of Bermuda. At less than 2km from the planned impact point, this was shockingly accurate for such an early test flight.

Steely and determined, Walter Schirra looks out into space on the ninth day of the mission

> “Schirra continued to disobey Mission Control, who told him: "It's your neck, and I hope you don't break it"”

▶▶ to him personally when I get back down". Eisele chipped in that one test was "ill-prepared and hastily conceived".

Going live

Early into the fourth day of the mission, the camera was finally switched on for the first live pictures ever transmitted from inside an orbiting American spacecraft. Six TV sessions were completed, despite the crew's nagging suspicion that NASA might be making too much space for publicity, at the expense of more urgent flight systems checks. NASA managers thought differently. American tax payers needed to see Apollo in action, they insisted. This wasn't the last time the astronauts and the space agency would clash over publicity requirements.

The worst of the arguments were glossed over at the time, and the astronauts made the best of their broadcasts. The public saw just their smiling, happy faces as they held up cards on which amusing messages were written: "Hello from the lovely Apollo room high atop everything" and "Keep those cards and letters coming in, folks". They showed their space food and filmed through a window so that viewers could see Earth rolling by below.

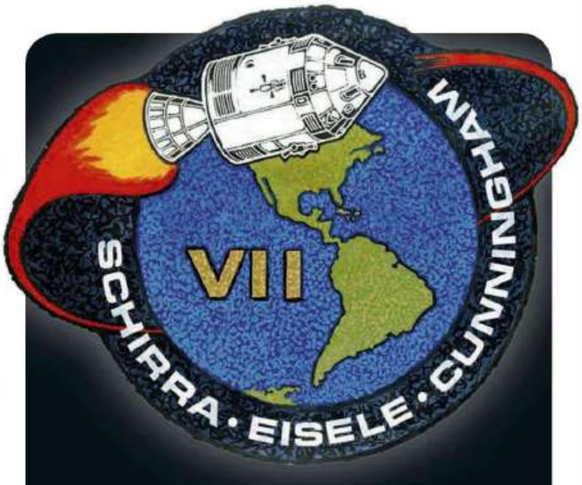
As Apollo 7 prepared to re-enter the atmosphere, Schirra insisted that the crew wouldn't wear their helmets because they wanted freedom to blow their noses and unblock their ears. Mission Control disagreed, warning Shirra: "You had better be prepared to discuss when you land why you haven't got them on." When Schirra continued to disobey he was told: "It's your neck, and I hope you don't break it."

Moving forward

Only in October 2008, some 40 years after the mission, did NASA honour Apollo 7's crew with its Distinguished Service Medal, an award that had been granted automatically to all other Apollo crews. It took all those years to acknowledge that Schirra, Eisele and Cunningham were justifiably preoccupied while testing a spacecraft that had so recently proved fatal. Apollo 7 showed that the spacecraft was ready at last for the daunting challenges ahead. NASA also realised that a greater level of trust, respect and understanding was needed between ground teams and astronauts if Apollo was to reach its goal without further disaster. ❂

ABOVE Apollo 7's splashdown is surprisingly accurate, landing just 2km from the planned impact point

RIGHT Navy personnel are on hand to hoist the Apollo 7 capsule aboard the recovery ship, USS *Essex*



MISSION BADGE

Originally, the Apollo 7 crew wanted their patch to represent 'rising from the flames' after the fire of Apollo 1. But the initial design of a spacecraft rising from a fireball was rejected for fear of being in bad taste. However, the patch still hints at the 'phoenix' theme with a ball of fire coming from the back of the spacecraft.

ABOVE The crew are congratulated by President Johnson, although it took 40 years for official recognition

LEFT NASA executives welcome back the crew, but relations between ground and flight staff had been fraught

The press site at Kennedy Space Center is the perfect viewpoint for news reporters and television cameras

21 December 1968

APOLLO 8

THE SECOND MANNED APOLLO MISSION SHOOTS FOR THE MOON

MISSION FACTS

OBJECTIVE: To orbit the Moon. The astronauts would be testing translunar injection, along with all the systems on board in preparation for future lunar flights. Theirs would also be the first manned flight to use the Saturn V rocket.

DURATION: 6 days, 3 hours, 42 seconds

COMMAND MODULE: CM-103

A flock of birds makes
a quick exit at the first
manned Saturn V launch

Apollo 7 had shown that the capsule was ready for a lunar voyage. The same could not be said of the Saturn V launch vehicle, which had demonstrated some alarming flaws during its unmanned test programme. Nevertheless, in late 1968, senior Apollo managers made an incredible decision. Next time the Saturn V lifted off, it would carry a crew and take them all the way to the Moon. When NASA chief James Webb first heard about this plan, he exploded in fury. "Are you out of your mind? You're putting our agency and the whole Apollo project at risk!"

Webb had good sense on his side, but data from the secret intelligence networks persuaded his successor, Tom Paine, that a swift launch was worth the risk. There were only months to go before John F Kennedy's famous "before this decade is out" deadline for a lunar landing would expire, and it seemed that the Russians were still in the game. Their gigantic N1 lunar booster was behind schedule, and no great threat to Apollo, but a smaller rocket, the Proton, looked like a contender. There was a chance that it could send a special single-seat Soyuz capsule around the Moon by early 1969. If a brave cosmonaut in a Proton-Soyuz made such a flight before Apollo, the world would acknowledge yet another Soviet triumph, following on from Sputnik and Yuri Gagarin.

On 14 September 1968, the Soviets sent an unmanned capsule around the Moon and returned it to Earth. Behind the scenes, the Soviet space effort was in disarray, although NASA had no way of knowing this at the time. The people of Apollo genuinely believed they were in an urgent race. There seemed no choice but to commit the Saturn V to a lunar mission as soon as possible. Apollo's spider-like Lunar Module wasn't yet ready, and the only option was for Apollo 8 to launch without it.

Intensive ground tests confirmed that redesigns to the fuel pipes feeding the Saturn V's engines ▶▶

> “Apollo's spider-like landing module wasn't ready, and the only option was for Apollo 8 to launch without it”

MEET THE CREW

COMMANDER
FRANK BORMAN

Borman was born on 14 March 1928 in Indiana, and joined NASA in 1962. Apollo 8 was his most famous flight, but he also commanded Gemini 7 in December 1965. Borman was key in repairing NASA's reputation after the Apollo 1 fire of January 1967. In 1970 he left NASA, becoming chief executive of Eastern Air Lines.

BACKUP CREW
COMMANDER
Neil Armstrong

COMMAND MODULE PILOT
JAMES LOVELL

Born in Ohio on 25 March 1928, Lovell joined NASA in 1962. He flew on Gemini 7 with Frank Borman, a mission that saw the first rendezvous between two spacecraft. A year later, he piloted Gemini 12 with Buzz Aldrin. In April 1970, he commanded Apollo 13, which famously suffered a mid-flight explosion before limping back to Earth.

BACKUP CREW
COMMAND MODULE PILOT
Edwin 'Buzz' Aldrin

LUNAR MODULE PILOT
WILLIAM ANDERS

A nuclear engineer, Anders was born in Hong Kong on 17 October 1933, and joined NASA in 1963. He served as Lunar Module pilot for Apollo 8, although there was nothing for him to fly because Apollo 8 didn't carry a Lunar Module. He left NASA in 1969 and took up senior roles in atomic energy.

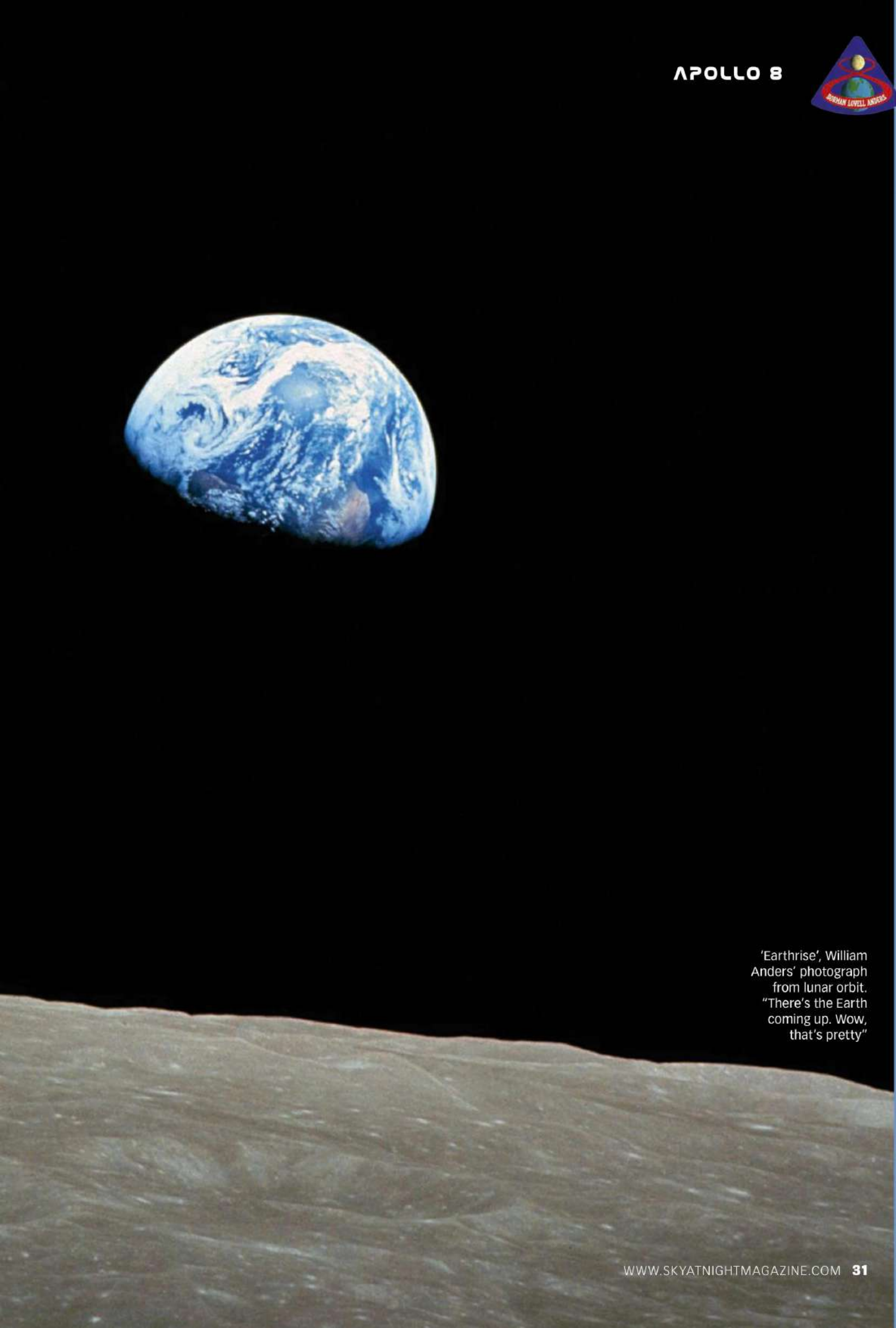
BACKUP CREW
LUNAR MODULE PILOT
Fred Haise

Mission Control is tense as Apollo 8 prepares to head into the unknown

The crew made 'home movies' on 16mm cameras, here capturing Lovell making observations

A previously unseen lunar section reveals peculiar craters of enormous diameter

The crew members were the first humans to see the dark side of the Moon with the naked eye



'Earthrise', William Anders' photograph from lunar orbit. "There's the Earth coming up. Wow, that's pretty"

MISSION TIMELINE

21 DECEMBER 1968
At 12:51 GMT precisely, the launch tower umbilicals and hold-down arms are released. Apollo 8 lifts off the pad atop a Saturn V rocket and begins a flawless ascent.

21 DECEMBER: 11 MINUTES
The Saturn V's third stage (S-IVB) shuts down its engine and Apollo 8 enters Earth orbit.

21 DECEMBER: 2 HOURS, 27 MINUTES
Mission Control's capsule communicator Michael Collins (later made famous on the Apollo 11 mission) relays the historic instruction: "All right, Apollo 8. You are 'Go' for translunar injection."

21 DECEMBER: 2 HOURS, 50 MINUTES
The S-IVB third stage relights its engine, hurling Apollo 8 out of Earth orbit towards the Moon.

24 DECEMBER: 68 HOURS, 58 MINUTES
Just two and a half days into the mission, Apollo 8 disappears around the far side of the Moon and radio contact is temporarily lost. Ten minutes and 14 seconds later, Apollo 8's Command Module engine is fired for four minutes, braking the spacecraft into lunar orbit.

24 DECEMBER
Using modified Hasselblad 500 EL cameras, the crew are able to capture high-resolution images of the far side of the Moon, including possible future landing sites.

25 DECEMBER: 89 HOURS, 19 MINUTES
After almost a whole day, and having completed 10 orbits of the Moon, Apollo fires its engine to escape lunar gravity, ready for a festive trip back towards the Earth.

25 DECEMBER 1968
A Christmas Day broadcast from inside the spacecraft unites the people of Earth in celebrating an epic achievement. "We are now approaching the lunar sunrise, and for all the people back on Earth, the crew of Apollo 8 has a message that we would like to send to you..." begins Bill Anders, before the crew read from the Book of Genesis.

27 DECEMBER: 147 HOURS
Apollo splashes down in the Atlantic, in rough seas, after 147 hours and 42 seconds. The parachutes drag the capsule upside down, but the flotation balloons in the nose eventually flip it upright. The crew are seasick, but otherwise in perfect health.

Much-loved anchorman Walter Cronkite headed up the Apollo 8 launch coverage, working from the Kennedy Space Center in Florida

> “The astronauts were disturbed that they could block the Earth from view, simply by holding up a thumb”

▶▶ would eliminate the vibrations that had ruined the most recent test flight, but it was still an extreme risk to launch the next Saturn with men aboard. However, there was no time left for another unmanned test.

First men to the Moon

On the morning of 21 December 1968, Apollo 8 took off on its epic journey. Command of the mission was entrusted to Frank Borman, a highly intelligent astronaut who had helped design the capsule. Borman's close relationship with the US Congress also kept angry politicians on NASA's side at a time when space seemed low on their priority list. His crewmates were James Lovell, who would later fly on the ill-fated Apollo 13 mission, and Bill Anders.

Apollo 8 was the first crewed ship to leave Earth and travel towards another world. On the second day of the mission, 77,000km from home, the crew sent back TV pictures of the Earth surrounded by murky blackness. The camera couldn't make out much more than a white blob, but it was still sensational.

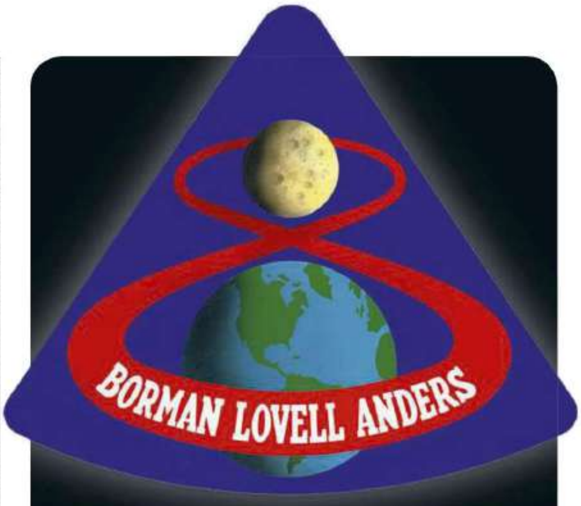
An experienced astronaut, Borman could get away with being a tough commander. At one point he told his crewmates to focus on their instruments: "I don't want to see you guys looking out the window." But when Borman wasn't looking, Lovell and Anders took sneaky glimpses at the dwindling form of Earth. They were disturbed that they could completely block it from view by simply holding up a thumb.

On Christmas Day 1968, all the world's TV stations carried a broadcast from Apollo 8, during which the crew read from the Book of Genesis. This didn't please atheists, but most people welcomed Apollo's achievement at the end of a doom-laden year plagued by the assassinations of Martin Luther King and Robert Kennedy, the Soviet invasion of Prague, global student riots and the Vietnam War.

Apollo 8 brought home something more precious than NASA had expected. Photographs of the Earth rising above the lunar horizon were printed in every newspaper and magazine. People began to appreciate just how lonely the Earth is. Bill Anders later observed: "We came all this way to explore the Moon, and the most important thing is we discovered the Earth." ❂

RIGHT As the spacecraft made its way back to Earth, television viewers were treated to this image of the planet

BELOW Apollo 8's re-entry was caught by a tracking system camera attached to an aircraft



MISSION BADGE

Astronaut Jim Lovell was a keen artist and sketched out the rough design as a passenger on a flight to Houston. He passed his doodles onto the team at NASA who came up with the final design. The figure of eight represents not only the mission number, but also the circumlunar route that they would be taking around the Moon.

YORKTOWN CVS-10

ABOVE The astronauts were presented with a celebratory cake after a successful splashdown

LEFT More than 2,000 people waited until after 2am to welcome the astronauts back to Ellington Air Force Base

The huge Saturn V stack is transported to the launch pad for take-off

3 March 1969

APOLLO 9

THE LUNAR MODULE MAKES ITS DEBUT IN ORBIT AROUND EARTH

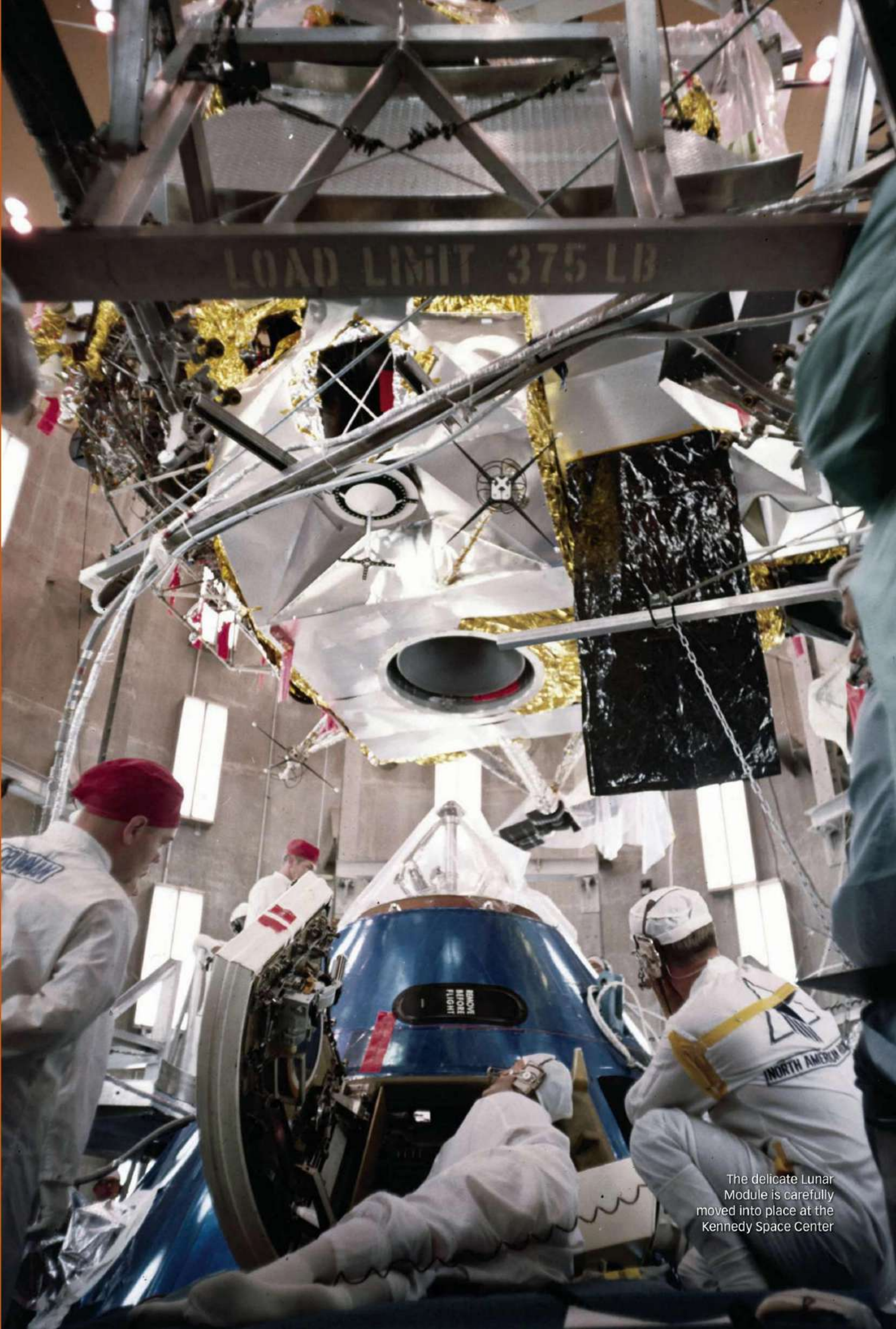
MISSION FACTS

OBJECTIVE: To test the docking and undocking of the Command Module and Lunar Module. The crew also conducted the first manned flight of the Lunar Module and tested it as a self-sufficient spacecraft.

DURATION: 10 days, 1 hour, 54 seconds

COMMAND MODULE: Gumdrop

LUNAR MODULE: Spider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REMOVE BEFORE FLIGHT
NORTH AMERICAN

The delicate Lunar Module is carefully moved into place at the Kennedy Space Center

Apollo 8's round-the-Moon mission during Christmas 1968 thrilled the world, but it didn't solve the ultimate challenge: how to land two men on the lunar surface and bring them back again safely. The answer lay with the bug-like Lunar Module (LM). However, it didn't help that the Grumman company's engineers were late delivering it. They could hardly be blamed – this was a completely new and unknown piece of technology with an incredibly demanding job.

Apollo 9's task was to check the LM's performance in the relative safety of Earth orbit. Jim McDivitt was in command, with Dave Scott responsible for the Command Module (CM) and Rusty Schweickart serving as LM pilot. Everyone at NASA kept their fingers crossed for a smooth flight. President Kennedy's famous "before this decade is out" deadline for putting men on the Moon was fast approaching. If the LM had any flaws at this late stage, there was precious little time remaining for Grumman to fix them.

On 3 March 1969, after a smooth lift-off and Earth orbit insertion, the time came to extract the LM, nicknamed Spider, from the Saturn V's upper stage. Scott had the job of swivelling the CM, Gumdrop, 180 degrees around so that it was facing the circular docking hatch on Spider's roof. But the CM's thrusters didn't appear to be working.

Scott was a veteran of Gemini 8, during which he and Neil Armstrong nearly lost their lives when a thruster got stuck in the 'on' position, spinning their ship out of control. Now he feared that another thruster problem would haunt Apollo 9. Fortunately, Mission Control discovered that the shock of lift-off had temporarily slammed shut the thruster propellant valves. McDivitt flipped the control switches off and on again and solved the problem.

> “ If the Lunar Module had any flaws at this late stage, there was precious little time remaining to fix them ”

The next unwelcome surprise was all too human. When it came to 'space sickness', it was impossible to predict who would suffer and who wouldn't. ▶▶

MEET THE CREW

COMMANDER
JAMES MCDIVITT

Born on 10 June 1929 in Chicago, Illinois, McDivitt flew 145 combat missions during the Korean War before joining NASA in 1962. He was command pilot for Gemini 4 in June 1965, and in 1969 he became overall manager for the Apollo programme. Leaving NASA in 1972, he moved into the world of corporate business.

BACKUP CREW
COMMANDER
Charles 'Pete' Conrad

COMMAND MODULE PILOT
DAVID SCOTT

A native Texan, Scott was born in San Antonio on 6 June 1932. He was an Air Force test pilot before joining NASA in 1963. In March 1966, he and command pilot Neil Armstrong overcame serious control problems during the Gemini 8 mission. Scott also commanded Apollo 15 and walked on the Moon. He has acted as a consultant for Hollywood movies.

BACKUP CREW
COMMAND MODULE PILOT
Richard Gordon

LUNAR MODULE PILOT
RUSSELL SCHWEICKART

Former aeronautical engineering student Schweickart joined NASA in 1963. He was born on 25 October 1935 in Neptune, New Jersey. Apollo 9 was his only space flight. He went on to become founder of the Association of Space Explorers, the international society of astronauts and cosmonauts, and the B612 Foundation.

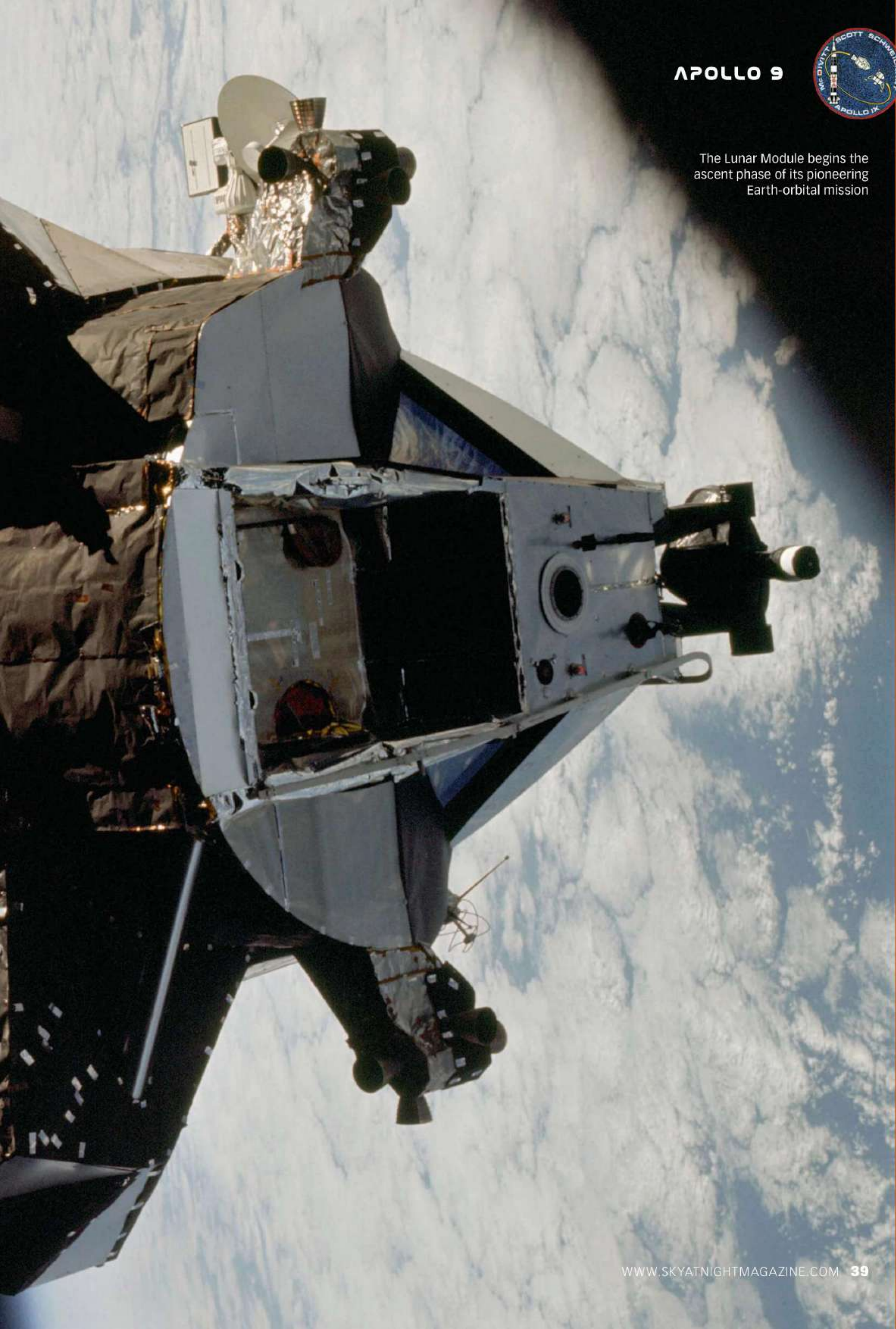
BACKUP CREW
LUNAR MODULE PILOT
Alan Bean

The astronauts take their final steps on Earth as they make their way to the waiting spacecraft

The launch pad is engulfed in smoke as Apollo 9 begins its mission into space

Mission Control was home to over 50 people working round the clock to ensure a smooth flight

The crew test newly developed television cameras, which would soon be used on the Moon



The Lunar Module begins the ascent phase of its pioneering Earth-orbital mission

MISSION TIMELINE

3 MARCH 1969

At 16:00 GMT precisely, the launch tower releases the Saturn V rocket and Apollo 9 lifts off the pad and begins a smooth ascent. A mere 11 minutes and 14 seconds later, the ship is in Earth orbit.

3 MARCH: 3 HOURS, 1 MINUTE

Apollo 9's Command Module (CM), Gumdrop, makes the first docking in space with the Lunar Module (LM), nicknamed Spider. An hour later, after careful systems checks, Gumdrop pulls Spider free of the Saturn's upper stage.

6 MARCH: 73 HOURS, 7 MINUTES

Now three days into the mission, LM pilot Rusty Schweickart – who was suffering from space adaptation sickness – begins a spacewalk, practising how to get in and out of the LM's forward hatch in a bulky space suit.

7 MARCH: 92 HOURS, 39 MINUTES

After three and a half days, and with McDivitt and Schweickart on board, Spider undocks from Gumdrop to begin a complex series of solo manoeuvres, including seven orbit adjustments, jettisoning the descent stage and firing the ascent stage's engine.

7 MARCH: 99 HOURS, 2 MINUTES

The two spacecraft re-dock successfully and Spider's crew transfers back into the CM.

7 MARCH: 101 HOURS, 22 MINUTES

Spider's ascent stage is jettisoned and Gumdrop continues the mission alone. For the next five days, the crew of Apollo 9 makes scientific observations of the Earth and conduct further tests of the CM's main engine.

13 MARCH: 240 HOURS, 31 MINUTES

After 10 days in space, the Service Propulsion System (SPS) engine on Gumdrop's rear is pointed in the direction of travel and fired for the last time to slow down the capsule prior to re-entry.

13 MARCH: 241 HOURS, 1 MINUTE

With re-entry initially delayed because of heavy seas in the prime recovery area, Gumdrop splashes down about 180 miles east of the Bahamas and only 5km and in full view of their recovery ship, the USS *Guadalcanal.*

The Lunar Module, Spider, is still attached to the Saturn V launch vehicle as it travels through space on the first day of the mission

> “They wanted to experience the emotional impact of being in space before they prepared for their homecoming”

►► Astronauts who hurled their guts up during ground tests could be fine in space, while those who satisfied the doctor's most sadistic checks before lift-off could easily throw up as soon as they went into orbit. Frank Borman, the tough commander of Apollo 8, had become sick on that mission, much to his irritation. This time Schweickart was the unlucky one, vomiting twice – a nasty business for him and his crewmates.

Fit for a walk?

The problem was that, on day three, Schweickart was scheduled to make a spacewalk. He was testing a procedure in which astronauts could transfer from the LM to the CM if, for any reason, the docking link failed to connect. Mission Control decreed that Schweickart make a less ambitious jaunt, crawling out of Spider's rectangular front hatch and standing on the little platform or 'porch' at the top of the lander's front leg, but not actually drifting across to the CM. Scott, meanwhile, poked his head out of Gumdrop's side hatch and looked across at Schweickart. Both took memorable photos of each other.

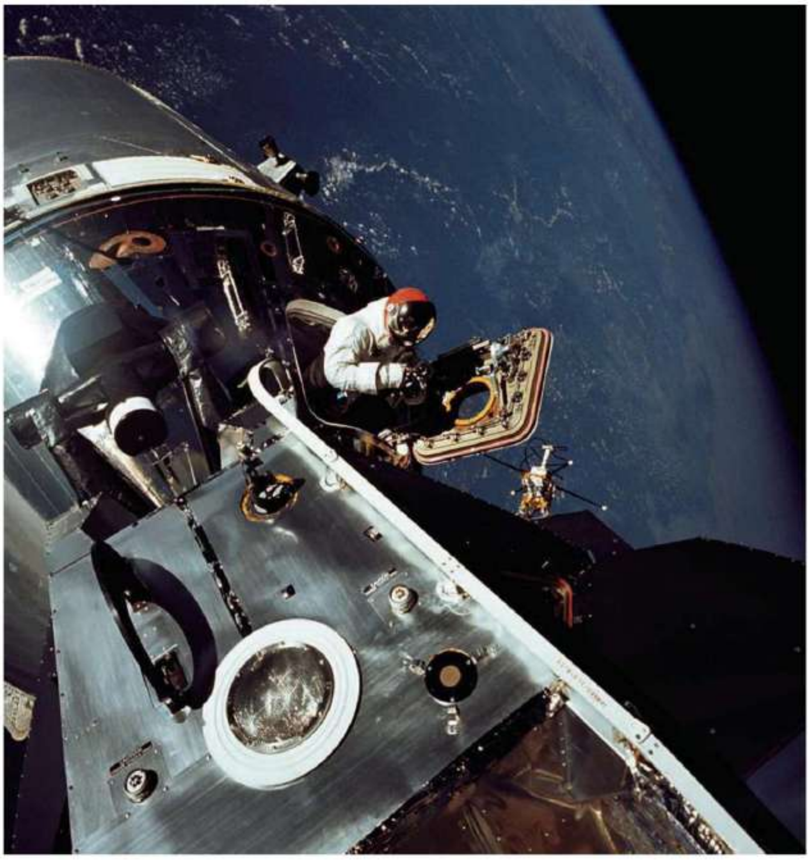
By the fifth day, 7 March, Schweickart had recovered his poise. He and McDivitt took Spider for a six-hour independent flight. The delicate machine proved that it was capable of all the manoeuvres needed for a lunar landing, plus that all-important rendezvous back with the CM mothership at the end of its mission.

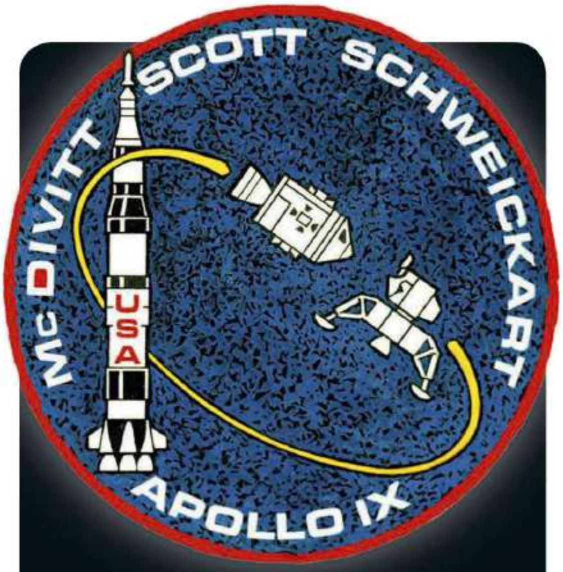
Even so, Scott was relieved when he saw sunlight glittering on the flanks of the LM's ascent stage as it headed back towards him after its solo adventure. “You're the biggest, friendliest, funniest-looking spider I've ever seen,” he radioed to his colleagues happily – although someone at NASA had failed to predict that the Sun would be shining right into Jim McDivitt's eyes as he tried to align the LM for re-docking.

The final five days of the mission were taken up with Earth observation and science experiments, but the crew also took time to dim the lights inside Gumdrop's cabin and look out of the windows at the Earth and the stars. They wanted to experience the emotional impact of being in space, before the relentless round of switch settings and thruster manoeuvres overwhelmed them as they prepared for their re-entry and homecoming.

On the 10th and final day in orbit, McDivitt said to Scott, “Dave, I'm exhausted. This is my last flight.” Scott sympathised completely.

In his 2004 autobiography *Two Sides of the Moon*, he wrote, “NASA made those missions look too easy. They were really, really hard.” ❸





MISSION BADGE

Unusually this patch features three spacecraft – the Command Module, the Lunar Module and the rocket launcher Saturn V. The use of all 3 crafts meant Apollo 9 was a 'type D' mission, hence the highlighted letter. The Moon landing was a 'type G' – Apollo 9 marked an over-halfway point and a huge development in getting man on the Moon.

ABOVE Schweickart captures Scott standing in the hatch of the CM as the Earth glimmers below him

RIGHT The mission is hailed a success as the astronauts splash down in the Atlantic Ocean

ABOVE The crew are collected, having landed just 5km from the recovery ship

LEFT Schweickart, Scott and McDivitt receive a red-carpet welcome

Stafford (left) and Cernan (right) make their final preparations before boarding the spacecraft

18 May 1969

APOLLO 10

SO NEAR AND YET SO FAR FROM WALKING ON THE MOON

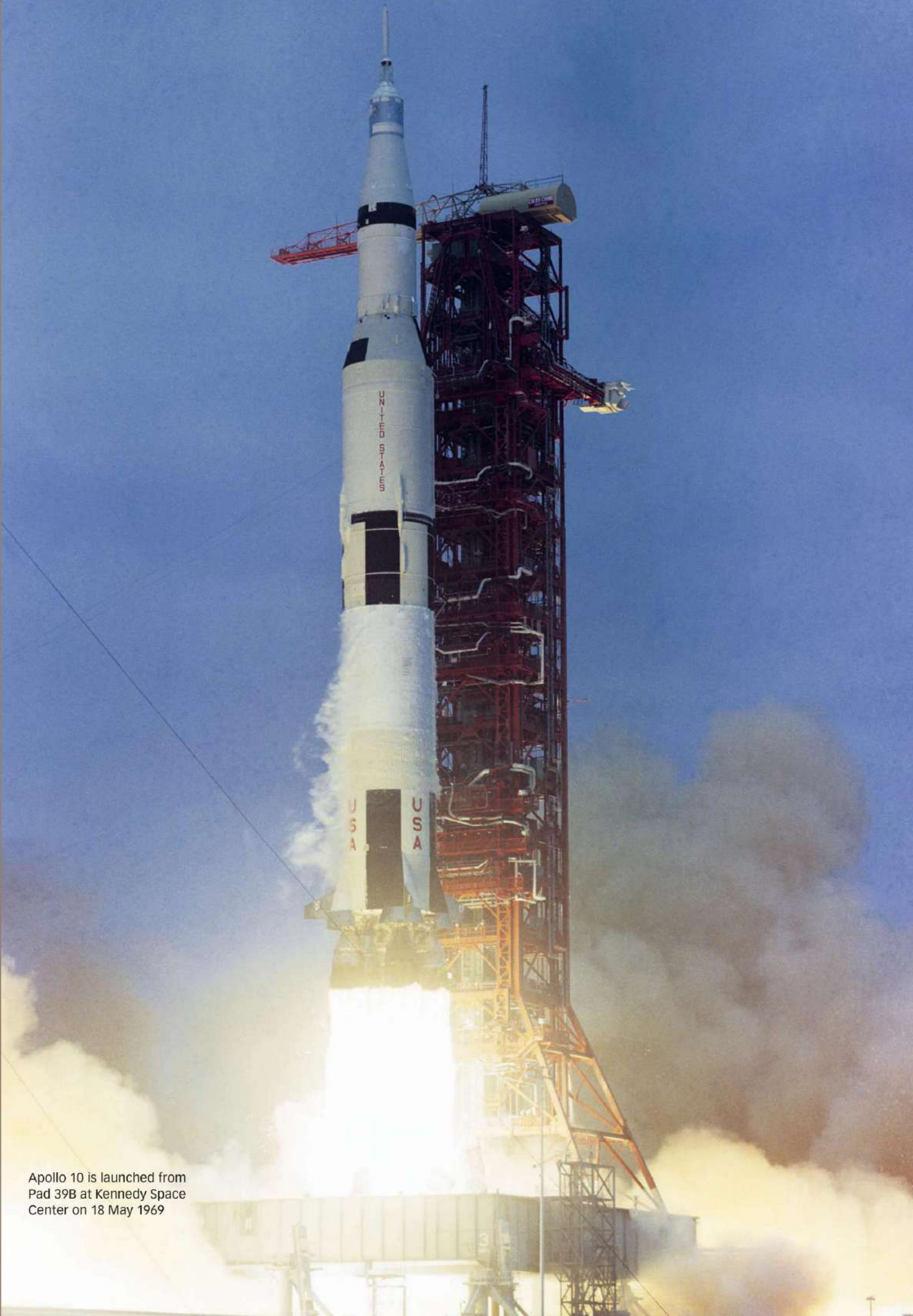
MISSION FACTS

MISSION OBJECTIVE: This was a dress rehearsal for Apollo 11. The crew would test all aspects of the Command Module and Lunar Module, but wouldn't land on the Moon.

DURATION: 8 days, 23 minutes, 23 seconds

COMMAND MODULE: Charlie Brown

LUNAR MODULE: Snoopy


UNITED STATES
USA
USA

Apollo 10 is launched from Pad 39B at Kennedy Space Center on 18 May 1969

Launched into space on 18 May 1969, Apollo 10 was the first mission to take a Lunar Module (LM) to the Moon. Its task was to approach tantalisingly close to the lunar surface without actually touching down. NASA needed to test the separation of the LM's ascent stage in case an emergency occurred while the machine was still in flight. The agency could not risk an actual landing unless this 'abort scenario' had been thoroughly rehearsed first. Tom Stafford was mission commander, with John Young flying Charlie Brown, the Command Module (CM), and Eugene Cernan piloting the LM, nicknamed Snoopy.

Minor dramas cropped up without any need to simulate scenarios. On 22 May, Apollo 10 was in lunar orbit and Stafford and Cernan were getting ready to undock from Charlie Brown prior to taking Snoopy on its eight-hour solo trip. They discovered that loose insulation jammed between the docking collars was bending the ships slightly out of alignment, possibly compromising the smooth mating of the air seal between them. If there was any damage inside those collars, the ships might never be able to reconnect again after undocking. Mission Control decided that the risk was slight, and Snoopy was sent on its way.

Two and a half hours later, Snoopy made a low-level pass over the Moon at an altitude of just 14.4km. Stafford and Cernan felt as if they could almost reach out and touch Mare Tranquillitatis, the Sea of Tranquility, as it skimmed past their windows, awaiting its moment of destiny. From his window seat inside Charlie Brown, Young caught sight of Snoopy 120km below, a tiny dot speeding across the Moon.

> “Apollo 10's task was to approach tantalisingly close to the lunar surface without actually touching down”

Computer confusion

Everything seemed to be going well, but when the time came to jettison the ascent stage after two more hours of close-approach manoeuvres,

▸▸

MEET THE CREW

COMMANDER
THOMAS STAFFORD

Born on 17 September 1930 in Oklahoma, Stafford was a pilot in the Air Force before joining NASA in 1962. Prior to Apollo, he flew on two Gemini missions. In 1975, he commanded the last Apollo capsule flight, docking with a Soviet Soyuz to mark the end of the Space Race. He left NASA later that year and became a space consultant.

BACKUP CREW
COMMANDER
Gordon Cooper

COMMAND MODULE PILOT
JOHN YOUNG

Young was born on 24 September 1930 in San Francisco. He graduated from the Georgia Institute of Technology with a degree in aeronautical engineering in 1952. He flew twice on both Gemini and Apollo, walking on the Moon with Apollo 16, and commanded the Space Shuttle twice. He worked for NASA for 42 years and died on 5 January 2018, aged 87.

BACKUP CREW
COMMAND MODULE PILOT
Donn Eisele

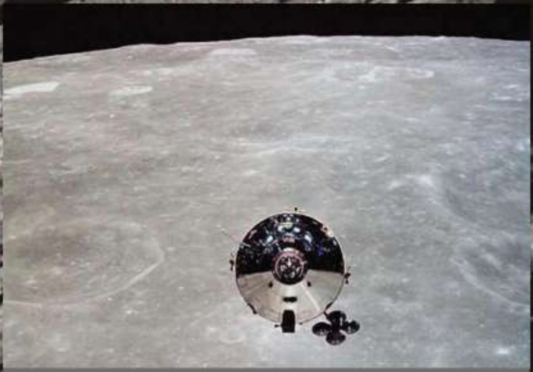
LUNAR MODULE PILOT
EUGENE CERNAN

Born in Chicago on 14 March 1934, Cernan studied electrical engineering at Purdue University and was chosen to be an astronaut in 1963. He was the co-pilot on Gemini 9A and, as commander of Apollo 17, became the last man to walk on the Moon. After NASA her went into business. He died on 16 January 2017, aged 82.

BACKUP CREW
LUNAR MODULE PILOT
Edgar Mitchell

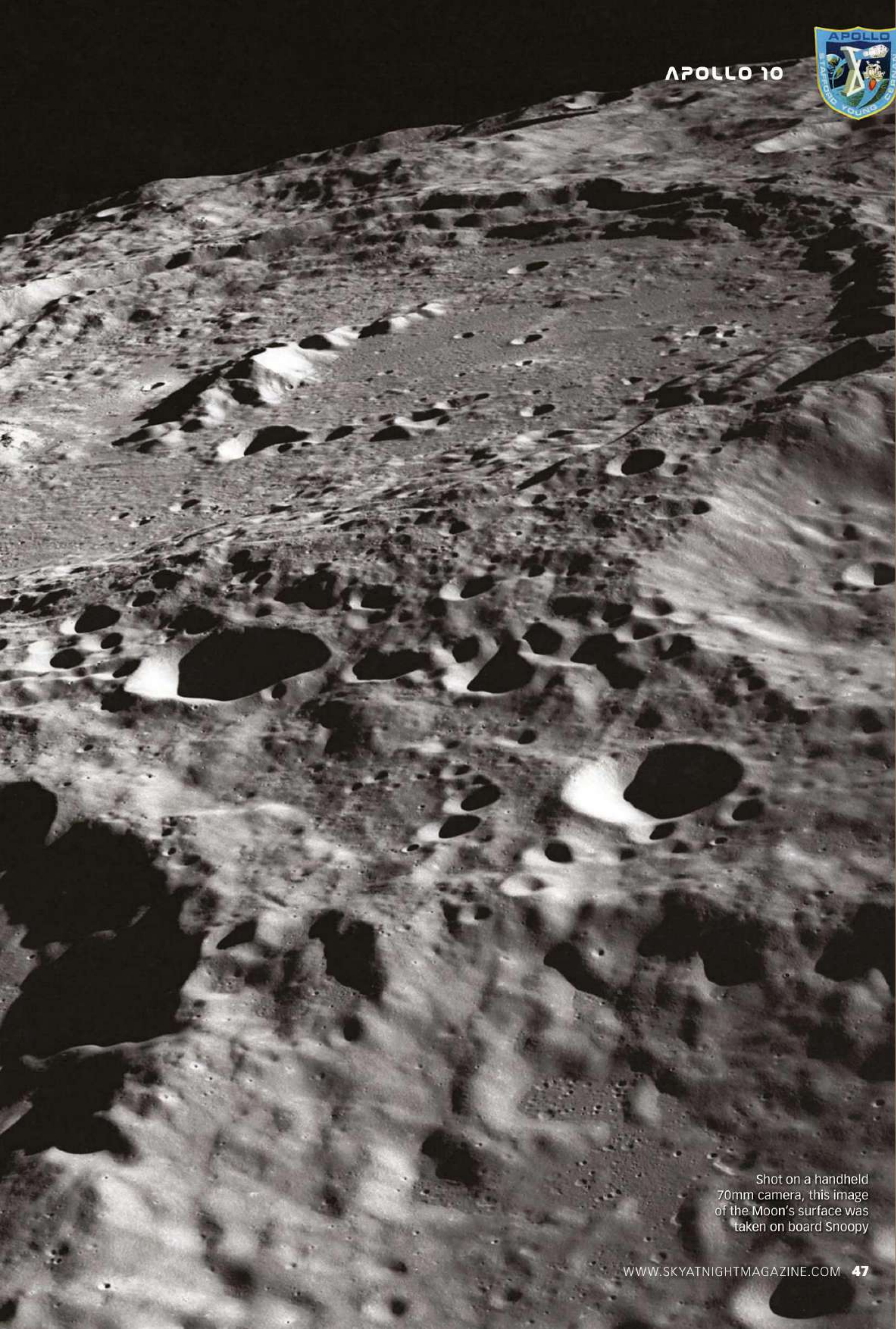
The Lunar Module came within a mere 14.4km of the Moon's surface before reascending

Young remained piloting Charlie Brown, over 120km above Stafford and Cernan in Snoopy



In this dress rehearsal, Stafford and Cernan came closer to the Moon than anyone ever had before

The crew took this photo of Earth from 160,934km – Europe and Africa are clearly visible



Shot on a handheld 70mm camera, this image of the Moon's surface was taken on board Snoopy

MISSION TIMELINE

18 MAY 1969
Lift-off occurs at 16:49 GMT. Apollo 10 reaches Earth orbit after 11 minutes and 53 seconds.

18 MAY: 2 HOURS, 39 MINUTES
The Saturn's S-IVB upper stage engine is re-lit, hurling Apollo 10 out of Earth orbit and on towards the Moon.

18 MAY: 3 HOURS, 6 MINUTES
The first colour TV transmission from space shows the blue of the Earth.

18 MAY: 3 HOURS, 17 MINUTES
Command Module Charlie Brown swivels 180° and docks with the Lunar Module Snoopy, and then extracts it from the S-IVB housing.

22 MAY: 80 HOURS, 25 MINUTES
Charlie Brown fires its Service Propulsion System engine against the direction of travel, allowing the Moon's gravity to capture the combined craft in a circular orbit.

22 MAY: 98 HOURS, 12 MINUTES
Despite some slight concern about the integrity of the docking hatches, caused by trapped fragments of insulation debris, Snoopy undocks to begin its solo expedition. Young remains in the Command Module.

22 MAY: 100 HOURS, 41 MINUTES
Snoopy makes its closest approach to the Moon, bringing Stafford and Cernan within 14.4km of the surface.

22 MAY: 102 HOURS, 45 MINUTES
After jettisoning the descent stage, Snoopy's ascent stage begins a frightening three-minute period of gyrations and instability. Stafford and Cernan regain control, though they're left slightly off course.

23 MAY: 106 HOURS, 22 MINUTES
Snoopy's computer instantly compensates for the drift and re-docks successfully with Charlie Brown.

26 MAY: 192 HOURS, 3 MINUTES
Charlie Brown splashes down in the Pacific just 6km from the prime recovery ship, USS *Princeton*.

In the thick of it: day one at Mission Control. Standing in the centre background is Dr Christopher Kraft, director of flight operations

> “For three tense minutes, the astronauts struggled to keep the gyros under safe limits and bring the craft under control”

▶▶ Snoopy's crew got the shock of their lives.

The LM's guidance computer was running under two opposing flight 'modes' simultaneously. The first mode calculated how to drop the LM safely towards the lunar surface. The second mode kept an eye on the CM orbiting overhead using upwards-pointing radar. It was exactly the kind of event that Apollo 10 was supposed to rehearse.

As soon as the depleted descent stage had been jettisoned, the ascent stage began gyrating wildly out of control. Snoopy's electronic brain had lost the plot, no longer certain if it was coming up from the Moon or still going down towards it. "Son-of-a-bitch!" Cernan swore loudly. "We're in trouble," Stafford reported. Warning lights alerted them that the gyroscopic navigation platform was being thrown around too violently for comfort. For three tense minutes, the astronauts struggled to keep the gyros under safe limits and bring the craft under control.

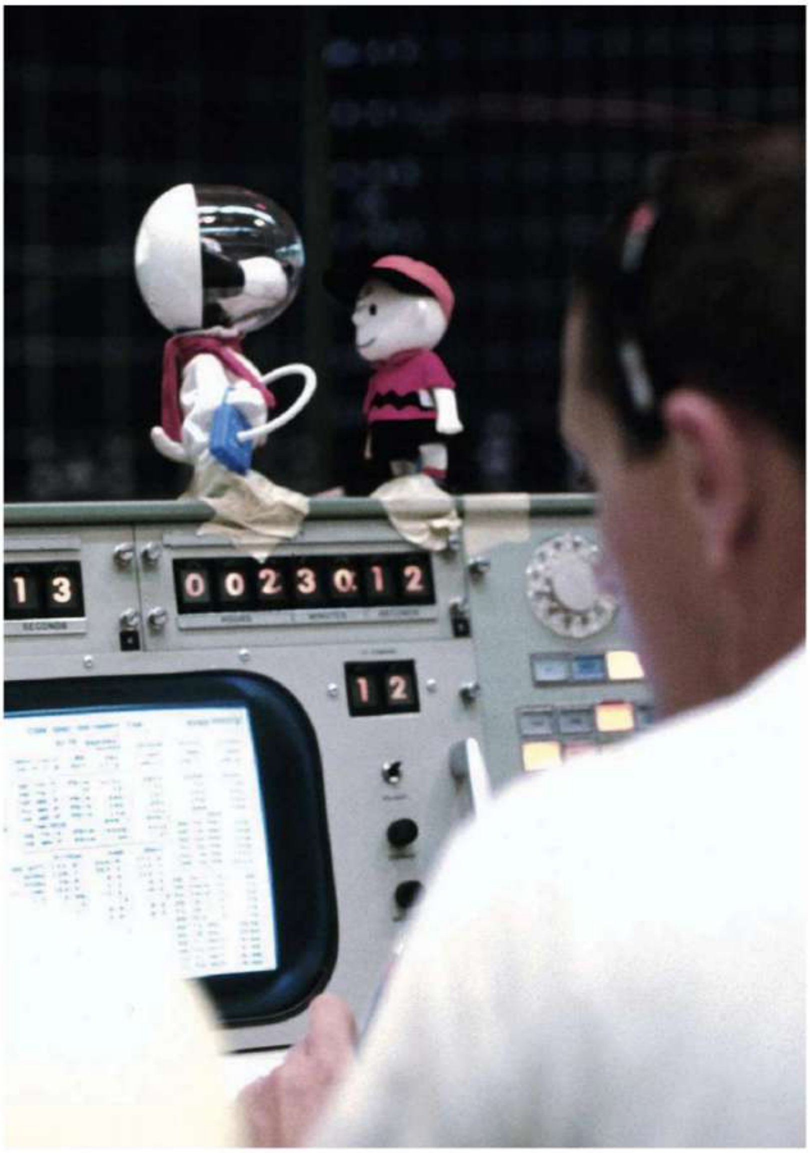
When the sickening motions halted at last, Stafford and Cernan found that the ascent stage had deviated slightly from the required trajectory. But the computer compensated flawlessly for the error, on its best behaviour once again. Charlie Brown came into view at just the right time, and the two modules' docking collars met with a satisfying thud.

The drama came down to a single switch in the wrong position. Unknowingly, both astronauts had responded to prompts from Mission Control to flip the switch when only one of them should have done. The net result was that it stayed in the same position and Snoopy's guidance systems were thrown into disarray.

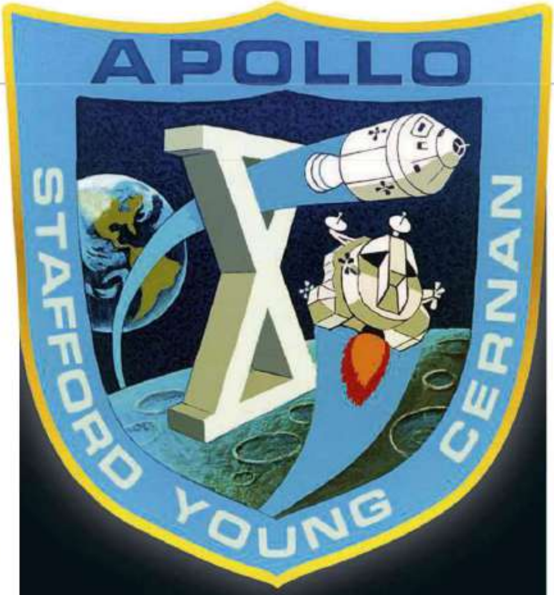
Mind your language

Meanwhile, back on Earth a pastor from Florida heard Cernan's "son-of-a-bitch!" outburst on the communications loop with the ground, and wrote to NASA to chastise the astronaut for his poor choice of words. After the mission, Cernan apologised. "I saw the lunar horizon go by about seven or eight times in 10 seconds, and that's a hair-raising experience," he said.

The NASA ground staff also felt the weight of history on their shoulders. With Apollo 10 completed, there were just 50 days before Apollo 11 was to lift off for the next challenge: landing a man on the Moon. And the three men taking part in Apollo 11 would be under the spotlight like no other explorers in history; they'd have to be sure to choose their words with more care, no matter what pressures were upon them. Ⓢ

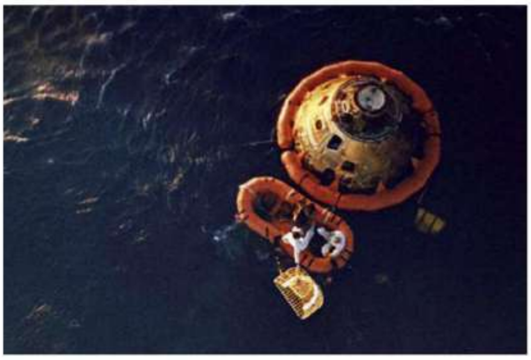


ABOVE Charles Schulz's Snoopy and Charlie Brown watch over their namesakes from the safety of Mission Control



MISSION BADGE

The technical design for Apollo 10 came from the crew's belief that the patch should be based more on the mechanics and goals of the mission. The astronauts and the philosophy of the space programme took a back seat for the first Apollo patch designed in the shape of a shield. It's often commented that this patch looks strikingly similar to Gemini 9A's patch – which wouldn't be surprising considering Stafford and Cernan were crew members on that flight too.



ABOVE Splashdown: the crew await pickup by the recovery helicopter

LEFT Following a successful mission, the Apollo 10 crew takes part in a parade through Cocoa Beach, Florida

"That's one small step for man, one giant leap for mankind."

16 July 1969

APOLLO 11

HUMANS STEP ONTO ANOTHER WORLD FOR THE FIRST TIME

MISSION FACTS

OBJECTIVE: To perform the first manned landing on the Moon.

DURATION: 8 days, 3 hours, 18 minutes, 35 seconds

LUNAR SURFACE TIME: 21 hours, 31 minutes, 40 seconds

COMMAND MODULE: Columbia

LUNAR MODULE: Eagle

We have lift-off! Apollo 11 blasts into the skies at 13:32 GMT on 16 July 1969

What if Apollo 11 had gone wrong? From launch on 16 July 1969 to splashdown eight days later, most of the mission was flawless – so much so that we have forgotten what the consequences might have been had it failed.

Time was running out on one of the most famous presidential pledges in history: to land a man on the Moon "before this decade is out". On 20 July, the Command Module (CM) Columbia and the Lunar Module (LM) Eagle had reached lunar orbit, and Neil Armstrong and Buzz Aldrin had undocked to begin their voyage down to the surface. From this point on, they could fly back up to Columbia at almost any time, except during a brief period known as the 'Dead Man's Zone'.

Within the final three minutes of the landing approach, there was a 10-second period when Eagle would be descending so fast that all its fuel would be exhausted trying to counteract the downward momentum. If anything went wrong during that 10 seconds, Armstrong and Aldrin would crash onto the surface of the Moon.

Twenty seconds before the Dead Man's Zone arrived, something did go wrong. A computer alarm lit up in the cabin. "Program alarm," said Armstrong. "1202," Aldrin confirmed. At Mission Control, 26-year-old Steve Bales was monitoring Eagle's computer systems. Senior flight controller Gene Kranz demanded to know "What's a 1202?", just as another alarm code flashed on Eagle's control panel. "Stand by," Bales replied. But Armstrong, well aware of the Dead Man's Zone rushing towards him, needed an answer. "Give us a reading on the 1202 alarm," he said. In other words he was asking if he should abort the landing.

If Bales was going to recommend an abort, he had to do so immediately. Making the swiftest and possibly the bravest decision of his life, he spoke into his headset for Kranz and all the ▶▶

> “Time was running out on one of the most famous presidential pledges…to land a man on the Moon "before this decade is out"”

MEET THE CREW

COMMANDER
NEIL ARMSTRONG

Armstrong joined the precursor to NASA in 1958 and flew the X-15 rocket plane, reaching the edge of space. Born on 5 August 1930 in Ohio, he commanded his first orbital flight, Gemini 8, in March 1966. After Apollo, he became a professor of aeronautical engineering. Armstrong died on 25 August 2012, aged 82.

BACKUP CREW
COMMANDER
James Lovell

COMMAND MODULE PILOT
MICHAEL COLLINS

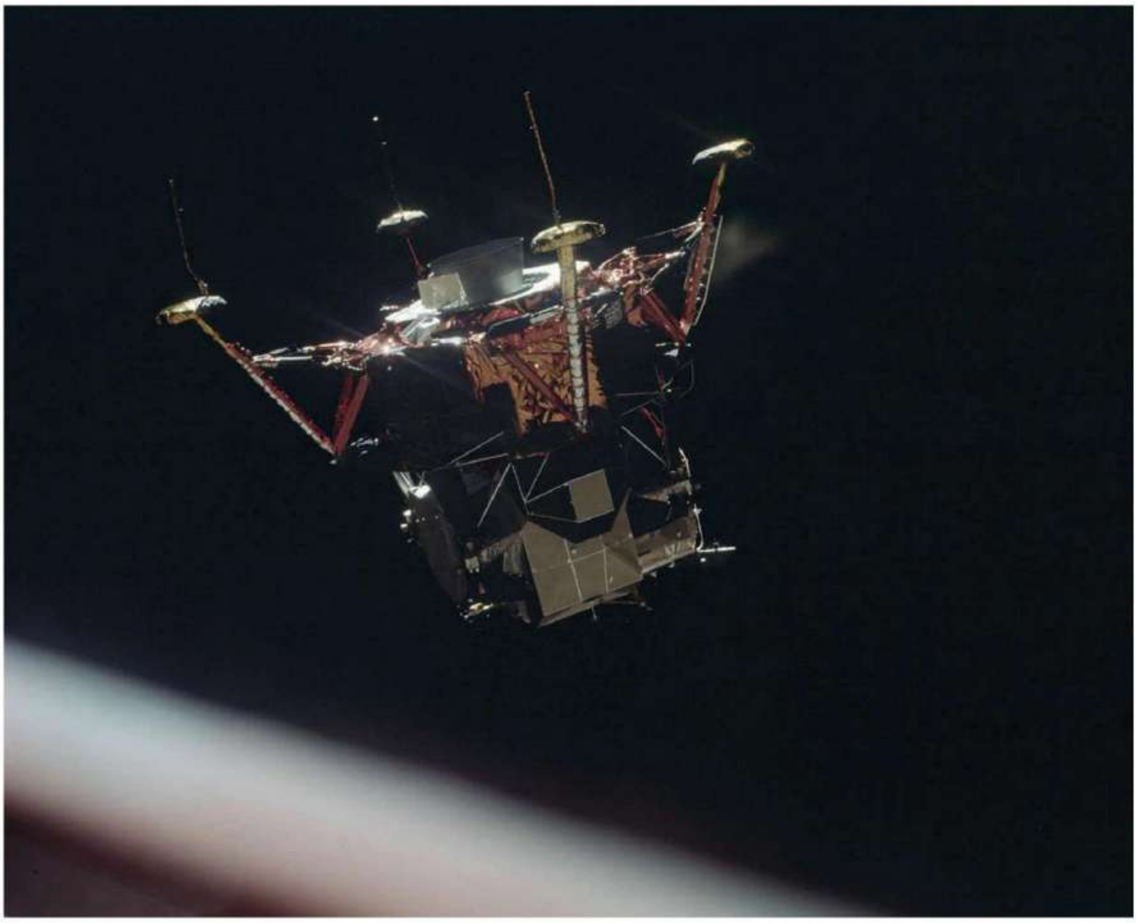
Collins was born into a military family on 31 October 1930 in Rome, Italy. He graduated from the West Point Military Academy in 1952, before becoming a test pilot. He joined NASA in 1963 and was co-pilot aboard Gemini 10. Collins retired from NASA in 1970 and became chief of the National Air and Space Museum, later starting his own consulting firm.

BACKUP CREW
COMMAND MODULE PILOT
William Anders

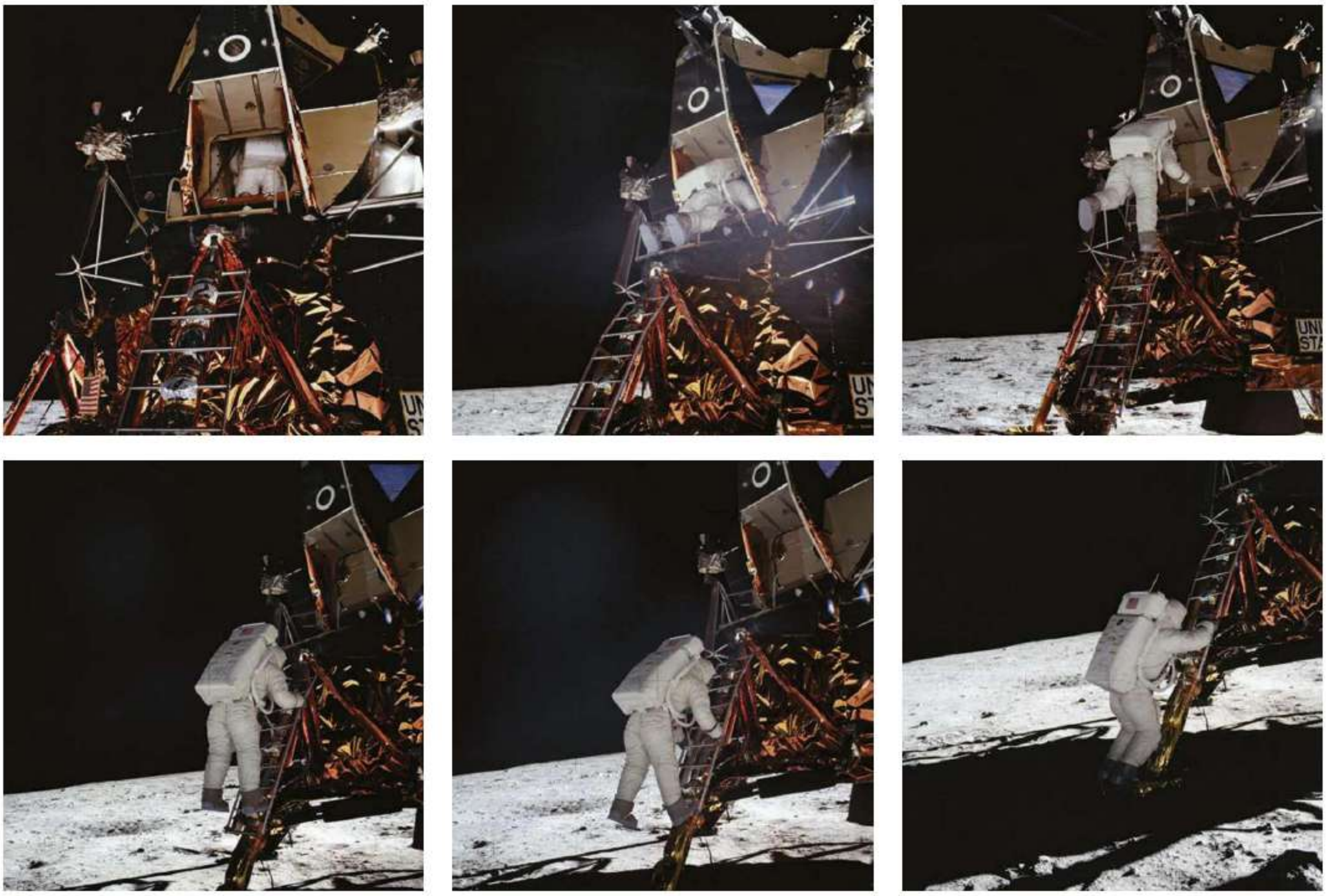
LUNAR MODULE PILOT
EDWIN 'BUZZ' ALDRIN

Born on 20 January 1930 in New Jersey, Aldrin attended West Point Military Academy before joining the US Air Force, flying combat missions in Korea. In 1963 he completed a doctorate in astronautics prior to joining NASA. Aldrin flew aboard NASA's Gemini 12 mission. Today he is a keen advocate of private space travel.

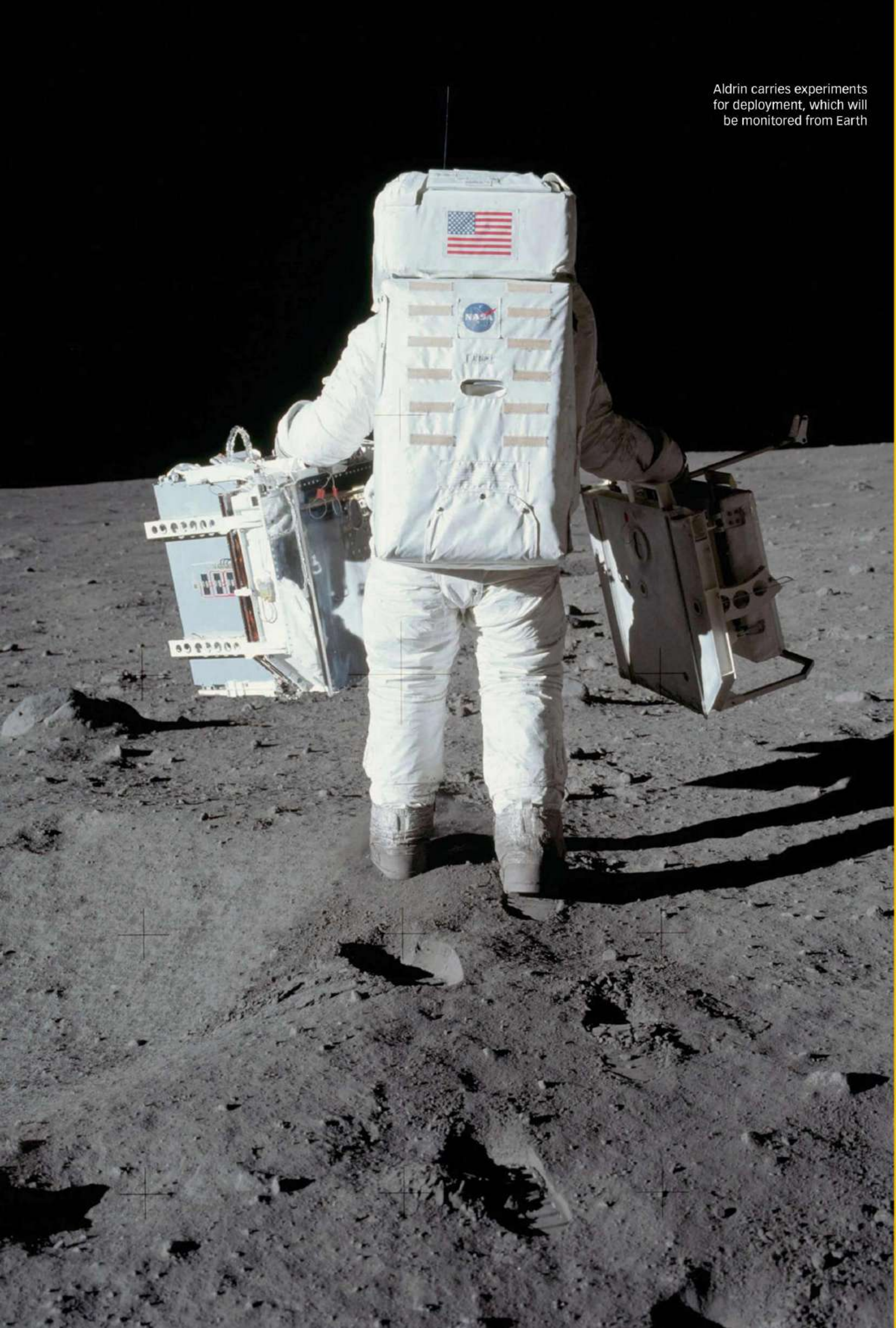
BACKUP CREW
LUNAR MODULE PILOT
Fred Haise



RIGHT Eagle, just after separation, begins the final leg of its journey to the surface of the Moon



BELOW LM Pilot Buzz Aldrin descends from Eagle onto the Moon



Aldrin carries experiments for deployment, which will be monitored from Earth

MISSION TIMELINE

16 JULY 1969
At least a million awestruck people throng the length of Cocoa Beach in Florida, near the launch site, to watch Apollo 11 lift off at 13:32 GMT.

16 JULY: 2 HOURS, 44 MINUTES
The hydrogen-fuelled S-IVB stage is ignited for a second time, pushing Apollo out of Earth orbit.

19 JULY: 75 HOURS, 49 MINUTES
The seven-minute braking burn into lunar orbit goes smoothly.

20 JULY: 100 HOURS, 12 MINUTES
With Armstrong and Aldrin aboard, Eagle undocks from Columbia and manoeuvres to allow Collins a clear view of the LM's condition, before drifting away to begin its descent.

20 JULY: 102 HOURS, 38 MINUTES
Eagle's guidance computer flashes the first of several '1202' and '1201' overload alarms, ramping up the tension for all concerned.

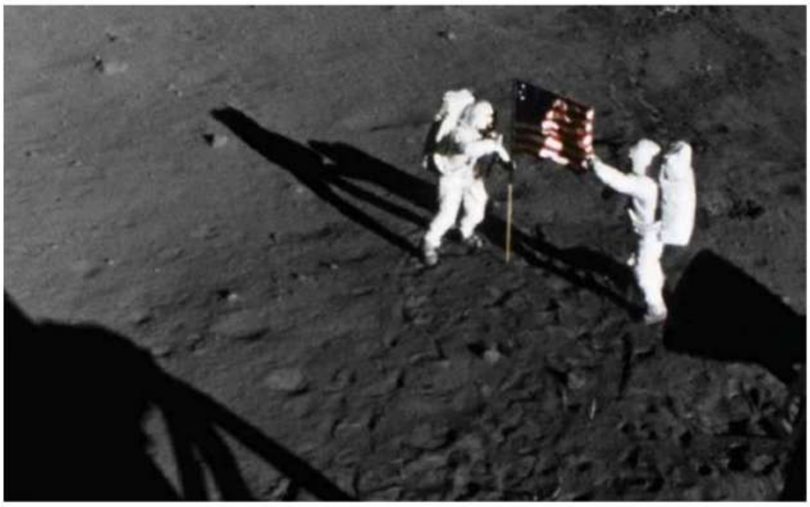
20 JULY: 102 HOURS, 44 MINUTES
Warning lights flash as Armstrong uses up precious fuel finding a safe place to land away from a large rocky crater.

20 JULY: 102 HOURS, 45 MINUTES
Touchdown is made on the Sea of Tranquility, about 6km from the predicted landing spot.

21 JULY: 109 HOURS, 24 MINUTES
Armstrong's boots touch the Moon. "That's one small step for man, one giant leap for mankind," he says. Aldrin joins him on the surface of the Moon 19 minutes later.

21 JULY: 111 HOURS, 39 MINUTES
Eagle's hatch is re-sealed after the 2-hour, 32-minute moonwalk. The astronauts had gathered 22kg of lunar surface material.

24 JULY: 195 HOURS, 18 MINUTES
Columbia returns to Earth and splashes down safely in the Atlantic.



Armstrong (left) and Aldrin plant the American flag. The moment is captured on film by a camera attached to Eagle

> “Just when the LM was supposed to be settling down, it shot forwards sickeningly fast. Had Neil and Buzz lost control?”

▶▶ controllers to hear. On the voice tapes that survive to this day, his voice is shaky and fearful: "We're 'Go' on that alarm," he announced.

Kranz was startled, but said nothing to contradict his young colleague. The computer carried on working, and Eagle plunged safely through the Dead Man's Zone. Just as Bales was recovering from that scare, capsule communicator Charlie Duke radioed a terse warning up to Eagle, hovering now on a plume of engine exhaust just above the surface: "Sixty seconds." In technical shorthand he was saying to Armstrong and Aldrin, "You only have 60 seconds of fuel left in your tank. You'd better land that thing."

Manual control

Kranz and his team then saw something even more worrying on their telemetry screens. Just when the LM was supposed to be settling down into the lunar soil, it shot forwards sickeningly fast. Had Neil and Buzz lost control of their ship?

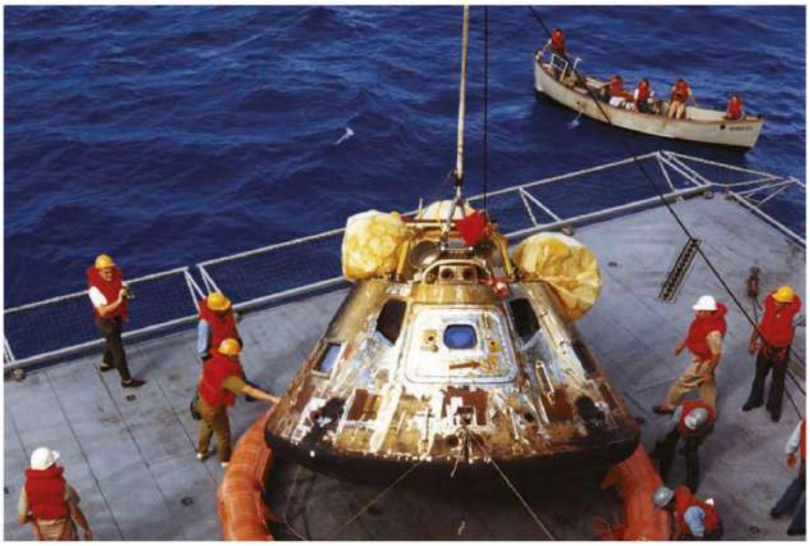
Another 10 seconds crawled by. At last, Aldrin radioed, "Contact light. OK, engine stop. Mode control both auto. Engine arm off." Those were the first words spoken by a human on another world, but history prefers to recall Armstrong's words a few moments later: "Tranquility Base here. The Eagle has landed."

Duke's response was almost lost among the whoops of delight. "Roger, Tranquility, we copy you on the ground. You got a bunch of guys about to turn blue. We're breathing again. Thanks a lot."

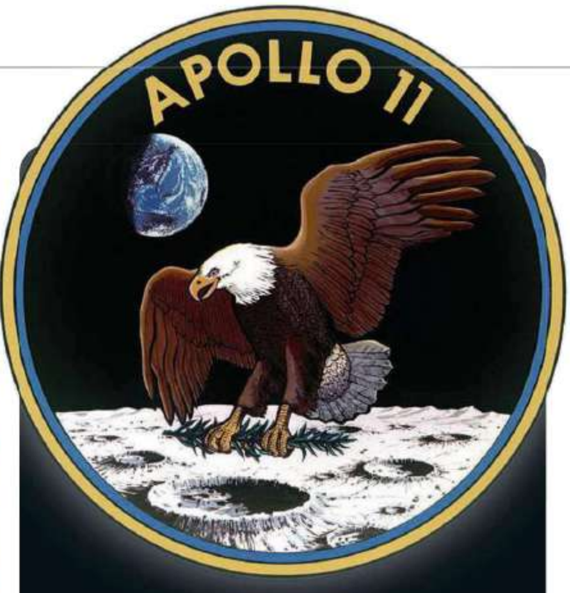
Armstrong was apologetic: "Houston, that may have seemed like a very long final phase, but the auto targeting was taking us right into a football field-sized crater with a large number of boulders and rocks." He needed a couple more seconds to hover a few metres above the surface and nudge Eagle forwards until he could find a safe place to land.

Houston needed no apologies. "Be advised, there are lots of smiling faces in this room," Duke replied. "There are two of them up here," said Aldrin. "And don't forget one in the Command Module," added Collins. His worst fear had been the prospect of flying back to Earth alone, the sole survivor of a space tragedy.

In just another nine months, the world would discover that missions to the Moon could go wrong, with explosive suddenness. But fortune was on Apollo 11's side. The late Arthur C Clarke once wrote: "An age may come when Project Apollo is the only thing by which most people remember the United States, or even the world of their ancestors, the distant planet Earth."

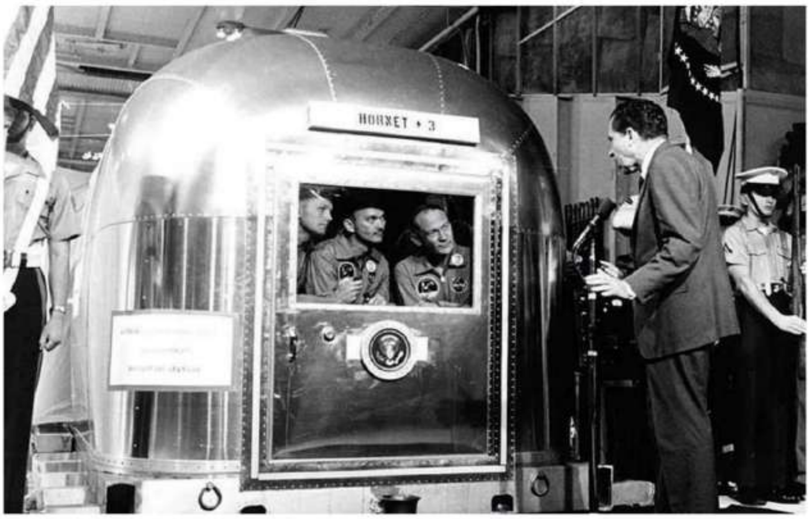


ABOVE Columbia is lowered onto the deck of USS *Hornet*, the prime recovery ship for the mission



MISSION BADGE

Crew member Michael Collins was the man behind this mission patch, after he saw a picture of an eagle in a National Geographic book. He said: "What do eagles do? They land." The golden eagle was given an olive branch to hold to symbolise peace despite Collins thinking it made the bird look awkward. This was the first mission to leave the crew's names off – they wanted everyone who had worked on the landing to feel included.



ABOVE President Nixon greets the Apollo 11 astronauts after their safe return. The astronauts are kept in quarantine for 21 days after their mission

ABOVE Collins, Aldrin and Armstrong relax in the quarantine van

LEFT A 37-day 'Giant Leap' tour kicks off in New York. The tour saw the crew travel to 23 different countries

The complete APOLLO Q&A

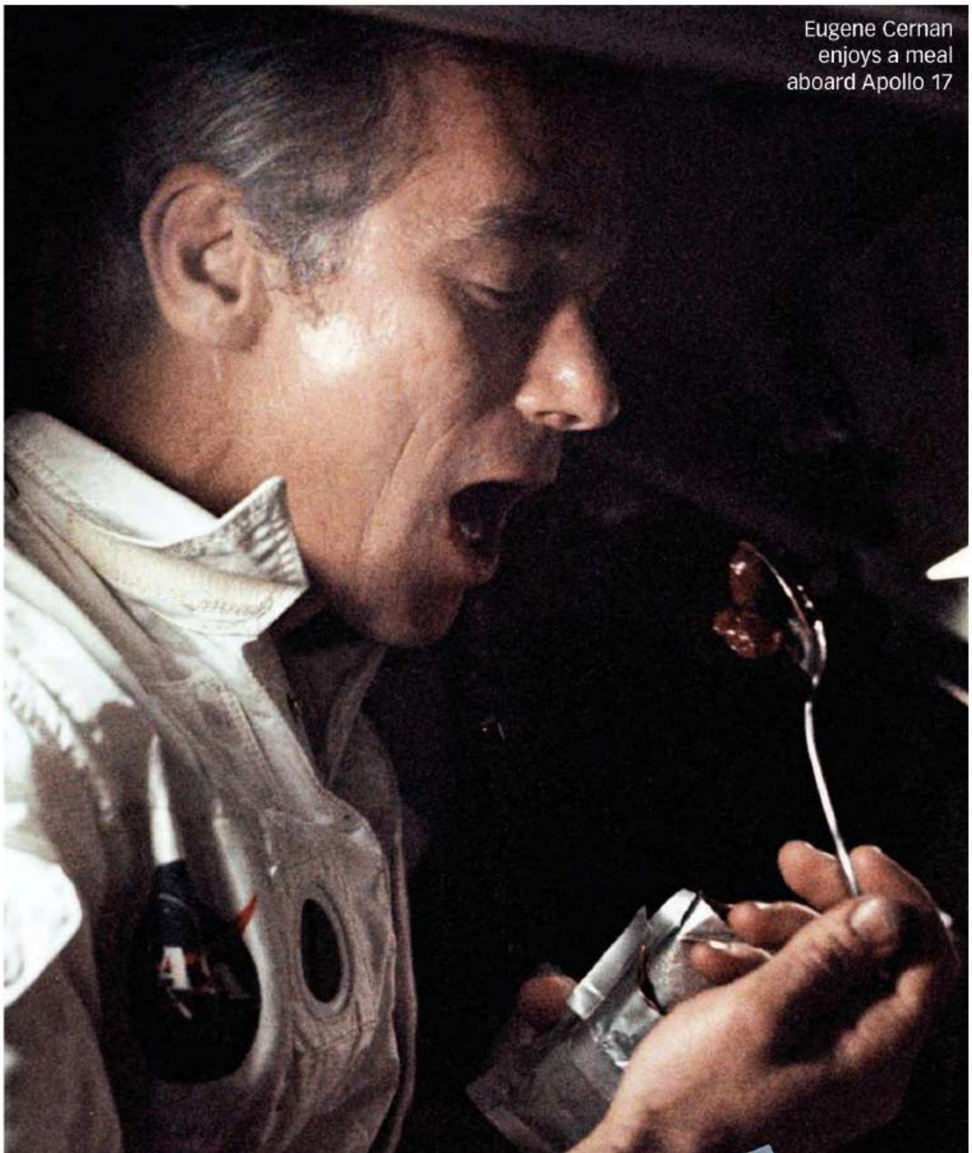
What was day-to-day life like for Apollo astronauts? Discover how they ate, trained, slept and more...

Q WHAT DID THEY EAT?

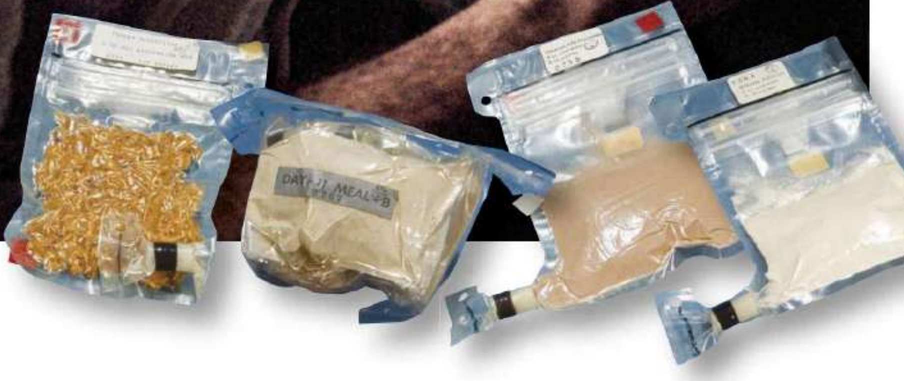
A Meals had to be lightweight, compact and suitable for zero gravity. Crumbs needed to be avoided at all costs in case they got into equipment and caused damage.

The Apollo 7 crew's diet was mainly made up of rehydrated foods such as shrimp cocktail and chicken salad. Although this might sound nice, it was closer in resemblance to baby food than a nice salad. Water was added into the packet, which was kneaded and then consumed out of a tube. The meals took too long to prepare and weren't popular. Thermo-stabilised 'wetpack' foods were introduced on Apollo 8. These were tastier and easier to make.

On Christmas Day 1968, the crew tucked into turkey and gravy with spoons. This was a breakthrough. The moisture in the food meant it stayed on the spoon even in zero gravity. The Apollo 11 crew were treated to cheddar cheese spread and frankfurters. Apollo 12 saw the addition of freeze-dehydrated scrambled eggs, which proved extremely popular. By Apollo 14, the lunar suits had an in-built drinking device that in the following mission would also include food bars in the suit neck. This enabled astronauts to keep up their fluid and calorie intake on the Moon.

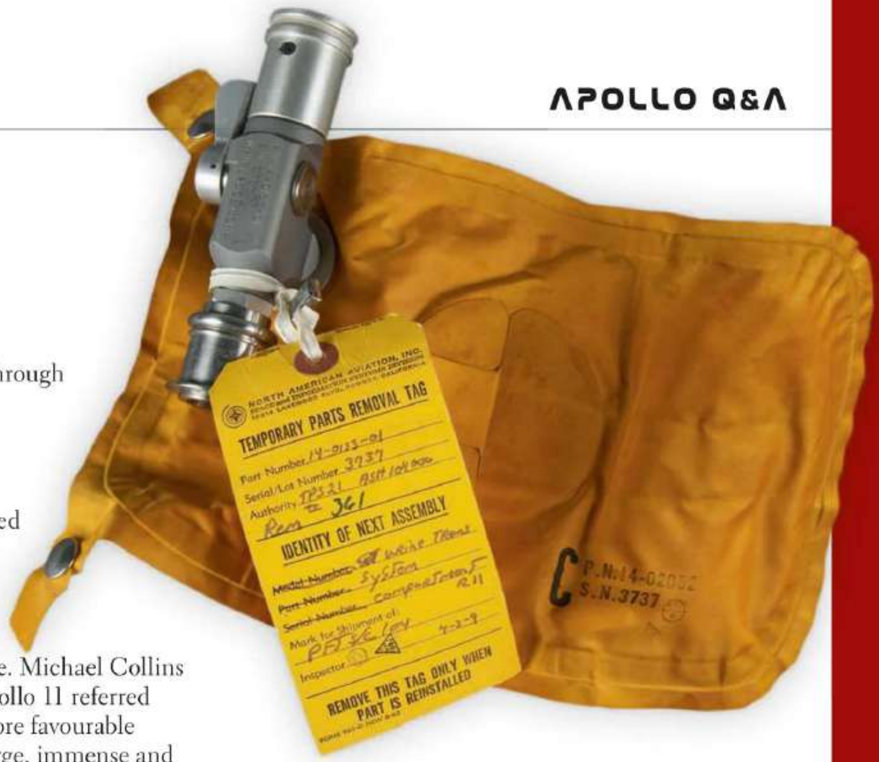


Eugene Cernan enjoys a meal aboard Apollo 17



RIGHT
The spoon-bowl package was first used on Apollo 10. Hot or cold water is added through the tube and the meal is then eaten out of the top using a spoon.

HOW DID THEY GO TO THE TOILET IN SPACE?


NORTH AMERICAN AVIATION, INC.
TEMPORARY PARTS REMOVAL TAG
IDENTITY OF NEXT ASSEMBLY
REMOVE THIS TAG ONLY WHEN PART IS REINSTALLED
S.N.3737

This was definitely one of the least pleasant aspects of life in space. For a number two, astronauts taped a plastic bag to their buttocks. The lack of gravitational pull was an issue that was never overcome on the Apollo missions. As a result, a finger-sized pocket had to be included in the side of the bag so the crewmen could separate themselves from their faeces once they were finished. They then had to pop in a capsule of germicide and knead the two together. The Apollo 7 crew returned with the memo "Get naked, allow an hour, have plenty of tissues handy…". Even with this advice it went wrong on Apollo 10, when astronauts encountered "A turd floating through the air". Twice.

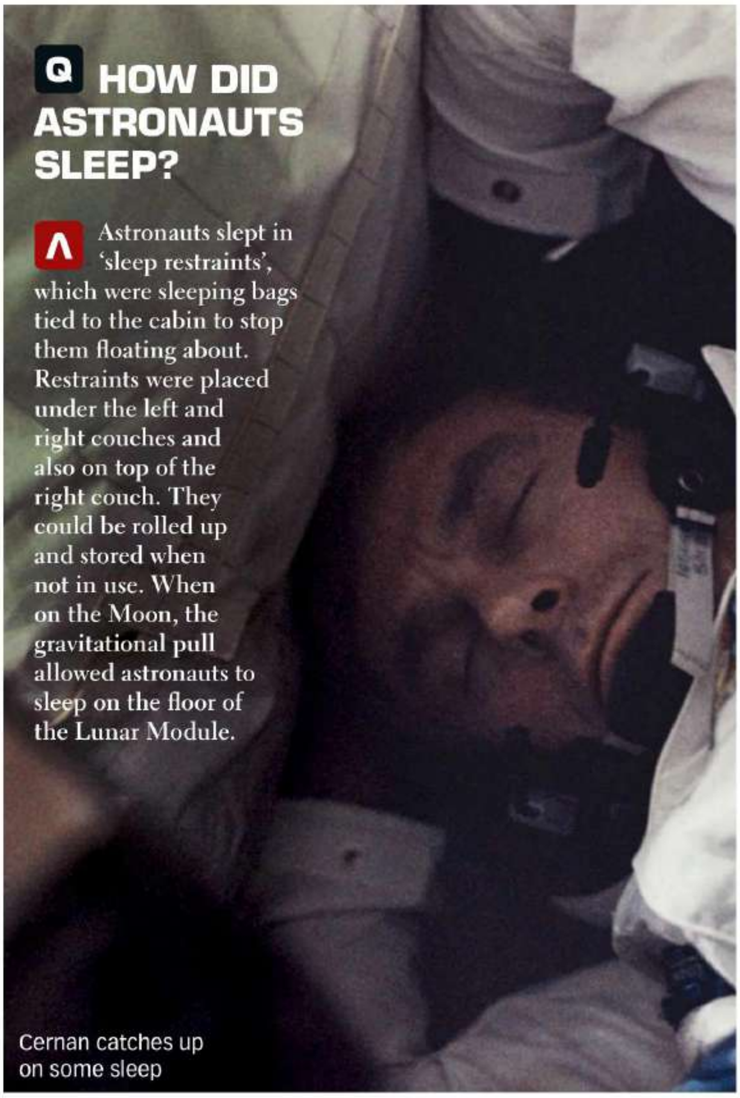
Urinating, in comparison, was much easier. Astronauts strapped on a rubber pouch, which came in three sizes – small, medium and large. Michael Collins remarked that Apollo 11 referred to them in the more favourable terms of "extra large, immense and unbelievable". These were attached to a hose that, when the valve was opened, would suck the urine into space. This wasn't as simple as it may seem. Open the valve too soon and your private parts would be painfully sucked in. Open it too late and urine droplets would float all over the spacecraft – and the unimpressed members of your crew.

A roll-on cuff attached to the metal valve as part of the urine transfer system

President Kennedy and NASA officials are briefed on Project Apollo

HOW MUCH DID THE APOLLO MISSIONS COST?

A preliminary cost of $7 billion was quoted. However, NASA administrator James Webb upped the estimate to $20 billion before handing it over to Vice President Johnson. Many were shocked by the cost, including the president, but Webb's estimate proved far more accurate. The final cost was reported to Congress in 1973 as $25.4 billion, which equates to roughly $140 billion (£110 billion) today.



HOW DID ASTRONAUTS SLEEP?

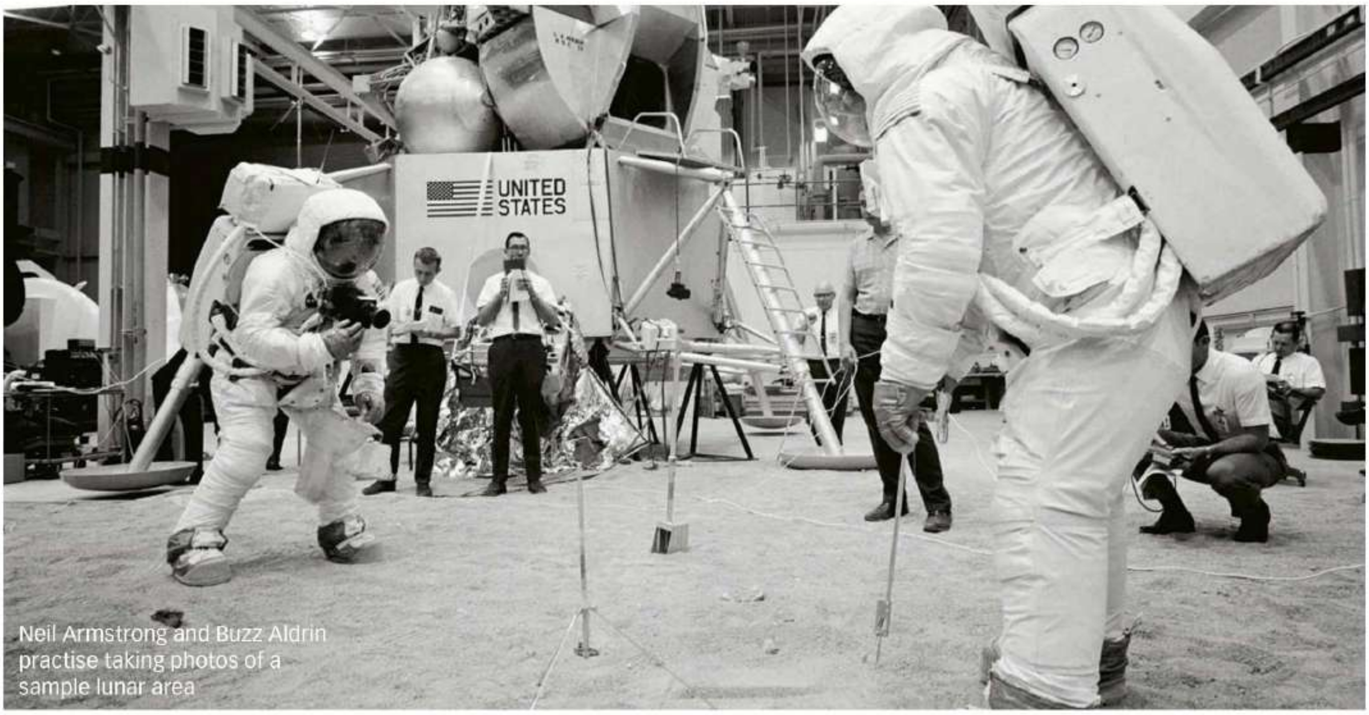
Astronauts slept in 'sleep restraints', which were sleeping bags tied to the cabin to stop them floating about. Restraints were placed under the left and right couches and also on top of the right couch. They could be rolled up and stored when not in use. When on the Moon, the gravitational pull allowed astronauts to sleep on the floor of the Lunar Module.

Cernan catches up on some sleep

Q HOW WERE ASTRONAUTS CHOSEN AND TRAINED FOR THE APOLLO MISSIONS?

A Potential astronauts were put through their paces in rigorous physical and psychological tests. They all had to meet the basic criteria of being 25–35 years old, under 5ft 11inches, hold a degree in engineering or physical science and have logged at least 2,000 flying hours with test pilot experience.

Their training was tough and varied. Astronauts were pushed to their limits in g-force training, learnt to manoeuvre themselves in zero gravity and even practised planting the flag. To recreate the lower gravitational pull of the Moon, astronauts were suspended sideways and had to walk along a wall. When Neil Armstrong landed, he commented that walking on the Moon was much easier than the training. Crew members underwent geology training and later Apollo teams went on Lunar Vehicle trips. The plan was for the crews to land in the sea, so a lot of time was spent practising getting out of model spacecraft in swimming pools or the Gulf of Mexico. However, in case they landed on land, all astronauts also had to learn jungle and desert survival skills.



Neil Armstrong and Buzz Aldrin practise taking photos of a sample lunar area

Q WHAT ABOUT PERSONAL HYGIENE?

A On board was a pack of dental floss, three toothbrushes and toothpaste that was safe to swallow.

The Apollo 10 crew were the first to shave in space. A lot of time and effort had been spent investigating electric razors. However, there was always the issue of bits of floating hair, which could have been a serious problem if they'd got into the machinery. Someone suggested using a razor and brushless shaving cream. This worked perfectly as the cream kept the hair together, which could then be wiped off.

Michael Collins has a shave after nearly eight days in space

Walter Schirra suffered from a cold on Apollo 7

DID ANYONE GET ILL IN SPACE?

Yes, all the crew of Apollo 7 had colds. Without any gravitational pull clearing the mucus, a cold in space is very unpleasant. The crew got increasingly grumpy and refused to wear their helmets during re-entry, so that they could blow their noses.

Motion sickness was quite common. On Apollo 8, Borman suffered from motion sickness and diarrhoea. His crewmates Lovell and Anders had to help him chase down particles of vomit and faeces, which were floating around the cabin.

Russell Schweickart demonstrates what astronauts wore on the Moon

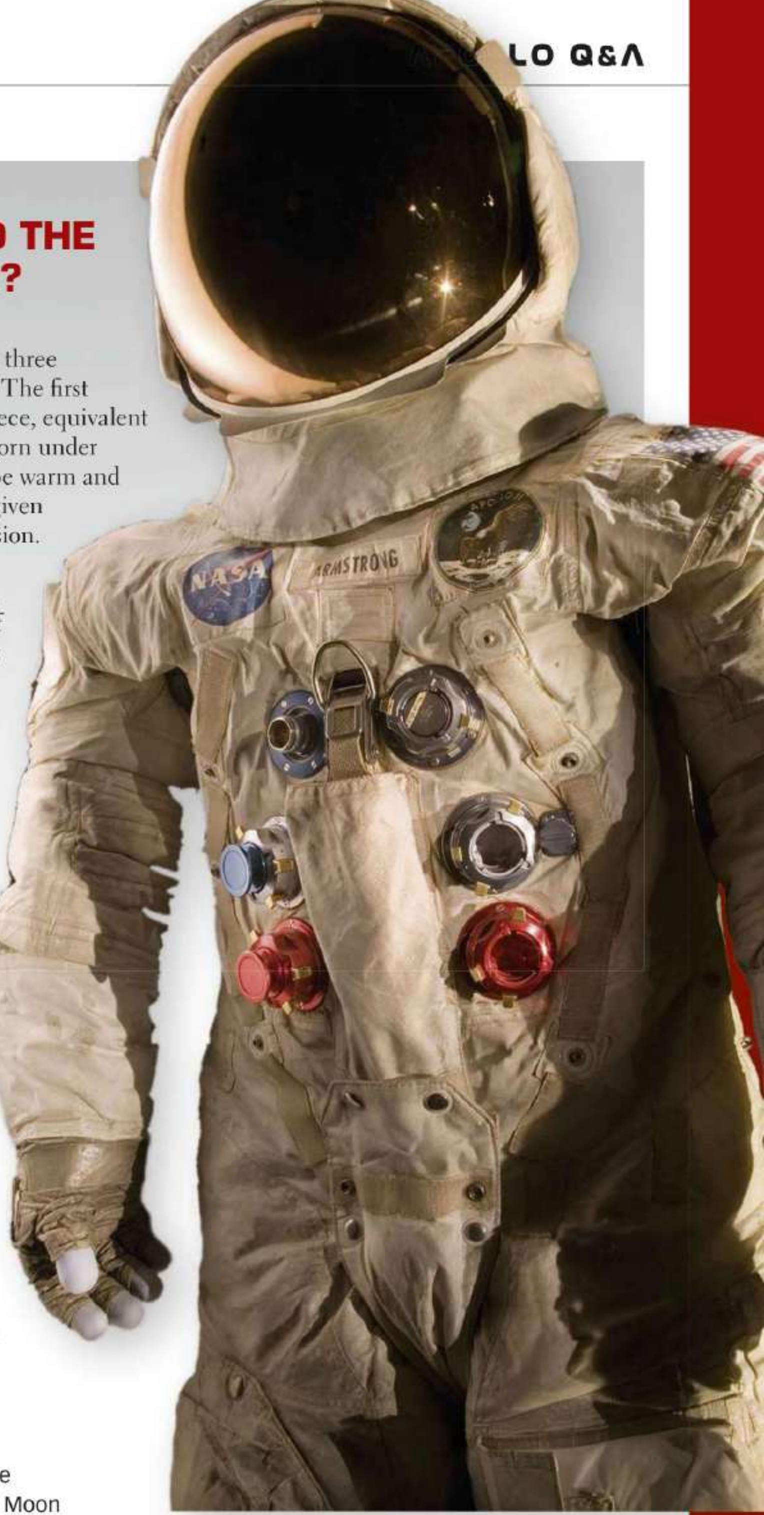
HOW DID THEY BREATHE?

The spaceship was pressurised with an on-board oxygen source that enabled the crew to breathe normally. When they were outside the spacecraft, astronauts wore a Portable Life Support System (PLSS), which was the large box on the back of the spacesuits. This provided them with oxygen to breathe in and removed the carbon dioxide they exhaled.

WHAT DID THE CREW WEAR?

The crew each had three tailor-made outfits. The first was a cotton all-in-one piece, equivalent to underwear. As it was worn under everything, it needed to be warm and comfortable. They were given two of these for each mission. The second was referred to as the 'inflight coverall garment' and consisted of a jacket, a pair of trousers and a pair of boots. This was made from Teflon as it was non-flammable and did not cause skin irritation. It was worn on board the spaceship.

Finally, there was the space suit. This one-piece, five-layer garment was worn during lift-off, re-entry and on the Moon. It offered a stable internal pressure, regulated temperature and also included a Maximum Absorbency Garment in case the crew needed to go to the toilet. After the tragedy of Apollo 1, the outer layer was non-flammable.

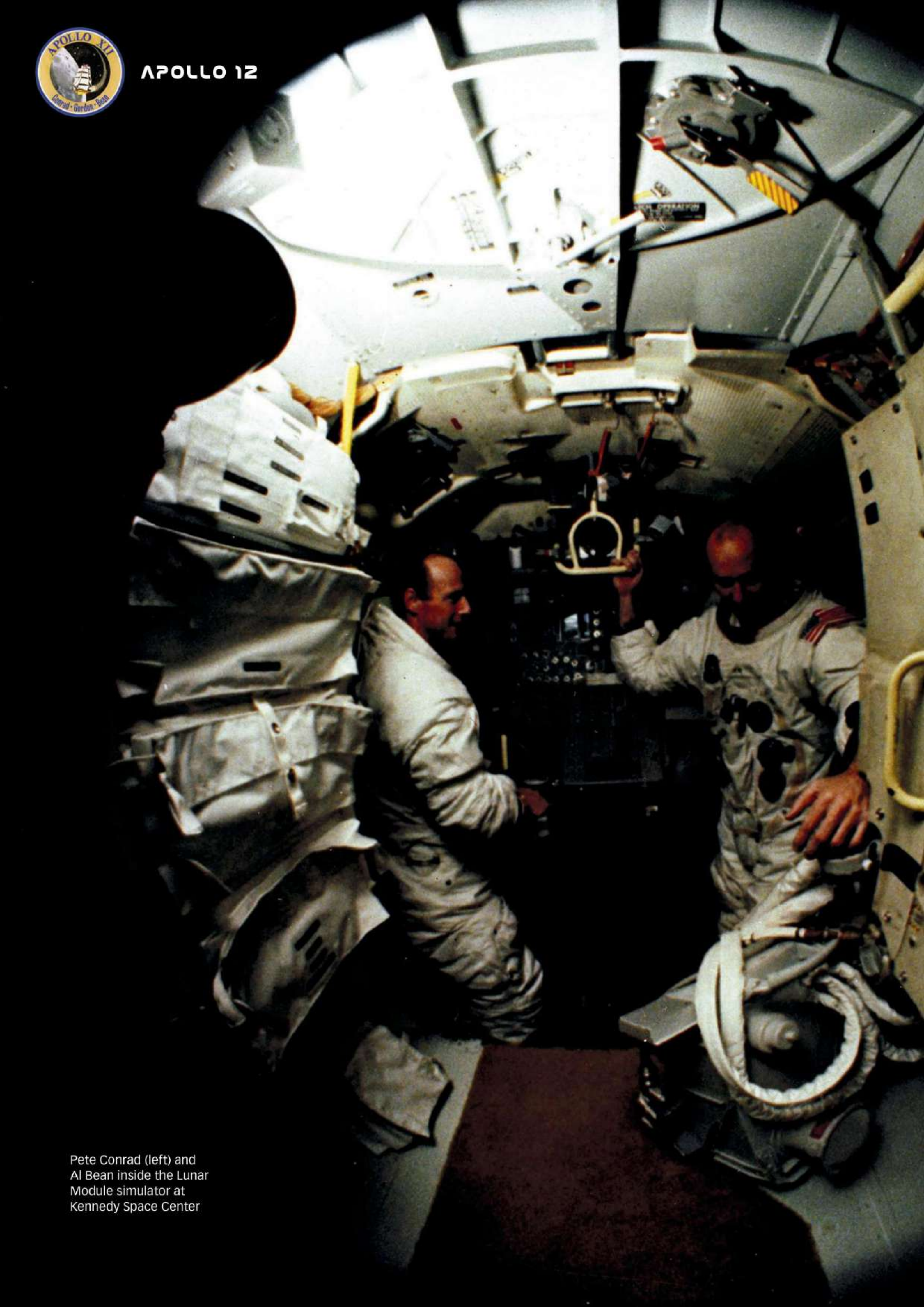


The space suit that Neil Armstrong's wore when he took the first steps on the Moon

Flight director Clifford Charlesworth in Mission Control during the launch of Apollo 8

HOW DID THEY COMMUNICATE?

Astronauts communicated in the same way pilots on Earth do – via radio. Range wasn't an issue as radio signals don't stop unless they are blocked. This meant that when the Command Module was orbiting the far side of the Moon, the Command Module pilot was unable to communicate with either the crew on the Moon or Mission Control.



Pete Conrad (left) and
Al Bean inside the Lunar
Module simulator at
Kennedy Space Center

14 November 1969

APOLLO 12

THE SECOND MOON LANDING COMES CLOSE TO DISASTER

MISSION FACTS

OBJECTIVE: To perform a precise manned lunar landing and complete a series of exploration tasks on the Moon.

DURATION: 10 days, 4 hours, 36 minutes, 25 seconds

LUNAR SURFACE TIME: 1 day, 7 hours, 31 minutes, 11 seconds

COMMAND MODULE: Yankee Clipper

LUNAR MODULE: Intrepid

Apollo 12 would be twice struck by lightning seconds after lift-off

The first men on the Moon were a shy test pilot and a demon-haunted workaholic. But there was never anything carved in stone to say that Armstrong and Aldrin would play those roles. Random crew rotations and the availability of hardware were major factors determining the astronauts' fates. If the jaunty and loveable crew of Apollo 12 had been first to land – and they so easily could have been – then NASA would have welcomed their skills as post-flight ambassadors for space.

The three astronauts inside Apollo 12's Command Module (CM), Yankee Clipper, were mission commander Pete Conrad, CM pilot Dick Gordon and Lunar Module (LM) pilot Al Bean. They'd known each other for many years, having been US Navy pilots together before joining NASA. They were perhaps the most perfect Apollo crew that NASA ever fielded.

The right stuff

As well as exceptional wit and charm, Conrad, Gordon and Bean had the usual astronaut qualities, such as not panicking when their ship was struck by lightning. This happened twice, about half a minute after lift-off in the wet and cloudy late morning of 14 November 1969. Two massive bolts of electricity struck the tip of the Saturn V rocket and travelled all the way to the ground, 1,000m below, down the column of hot gases in the rocket's immense exhaust plume.

As Conrad recollected some time after the mission: "I heard the master alarm ringing in my ears and glanced over to the warning panel, and it was a sight to behold."

> “Every warning signal was on, lighting up the capsule's interior like a shop window at Christmas”

Every warning signal was on, lighting up the capsule's interior like a shop window at Christmas. Mission Control was poised to call an abort, in which the launch escape tower would haul the capsule and its crew to safety. Afterwards, the Saturn V would be deliberately exploded by ▸▸

MEET THE CREW

COMMANDER
CHARLES 'PETE' CONRAD

Born on 2 June 1930 in Philadelphia, Conrad studied aeronautical engineering at Princeton. Joining NASA in 1962, he was the co-pilot for Gemini 5 in 1965 and commander of Gemini 11 in 1966. In 1973, he commanded the first mission aboard Skylab, America's first space station. Conrad died on 8 July 1999, aged 69.

BACKUP CREW
COMMANDER
David Scott

COMMAND MODULE PILOT
RICHARD GORDON

Gordon was born on 5 October 1929 in Seattle. He studied chemistry at the University of Washington and came to NASA via the US Navy in 1963. He was Conrad's co-pilot for Gemini 11 in 1966. As the Apollo era drew to a close, he left NASA in 1972 to pursue a business career in varied industries from sport to oil. He died on 6 November 2017, aged 88.

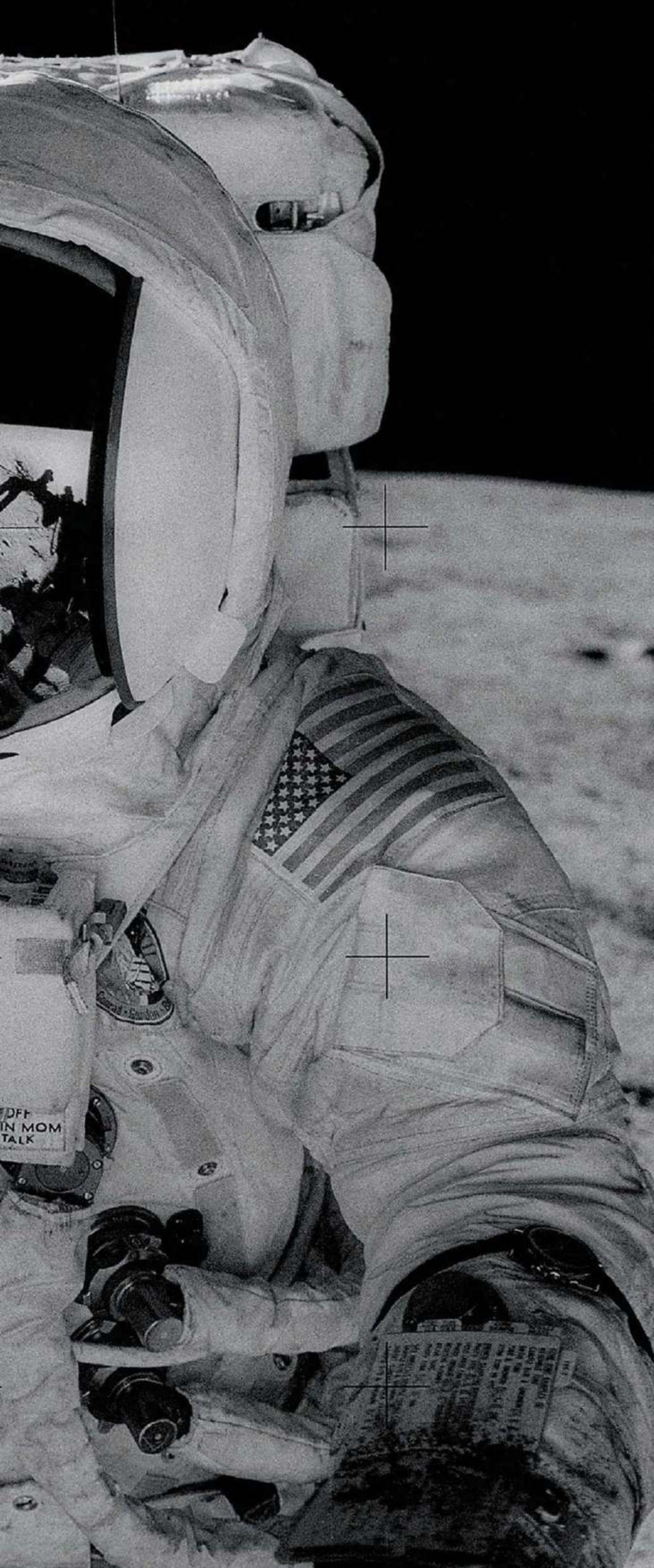
BACKUP CREW
COMMAND MODULE PILOT
Alfred Worden

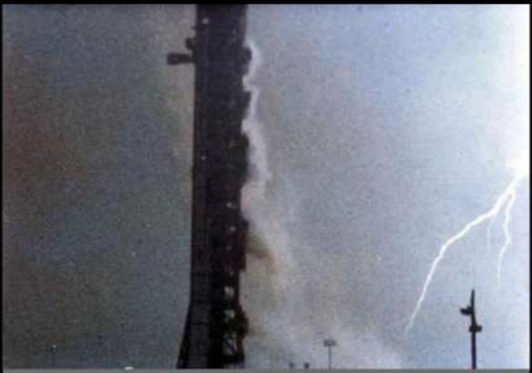
LUNAR MODULE PILOT
ALAN BEAN

Native Texan Al Bean was born on 15 March 1932. He studied aeronautical engineering at the University of Texas and was a US Navy pilot before joining NASA in 1963. In 1973, he commanded the second tour of duty aboard Skylab. Bean resigned from NASA in 1981 to become a painter and died on 26 May 2018, aged 86.

BACKUP CREW
LUNAR MODULE PILOT
James Irwin

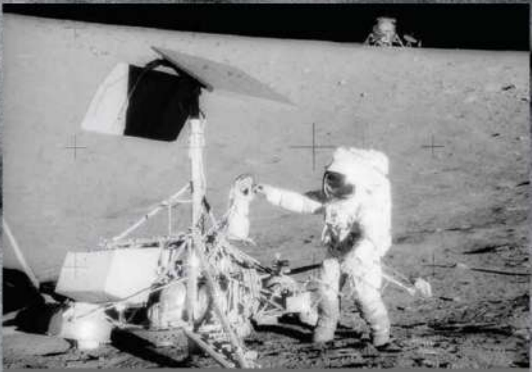
Al Bean collects lunar soil samples to return to Earth



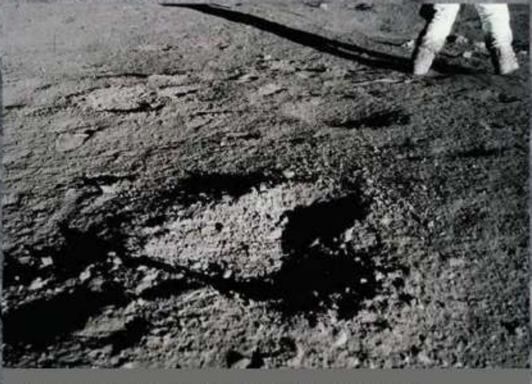


Shortly after lift-off, the Saturn V is struck twice by lightning, triggering electrical mayhem on board

Technicians in the Firing Room listen to Apollo 12 and Mission Control overcome electrical problems



Conrad examines the robotic lander, Surveyor 3, which has been on the Moon for over two years



Moon love: the astronauts discover a heart-shaped depression in the lunar surface

MISSION TIMELINE

14 NOVEMBER 1969

Apollo 12 lifts off at 16:22 GMT. At 36 seconds the mission appears to be seriously endangered when a lightning bolt strikes the rocket, disrupting the capsule's electronics. Sixteen seconds later, another bolt strikes.

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14 NOVEMBER: 11 MINUTES, 43 SECONDS

Apollo 12 achieves orbit using the Saturn V's independent guidance system between the third stage (S-IVB) and the adaptor containing the Lunar Module (LM). Once in orbit, the crew successfully resets the capsule's guidance systems.

14 NOVEMBER: 2 HOURS, 53 MINUTES

The upper S-IVB stage is fired for a second time, pushing Apollo 12 towards the Moon. Mission Control remains concerned that the lightning may have damaged the electrics for the re-entry parachutes, but there is little point in worrying for now.

19 NOVEMBER: 107 HOURS, 54 MINUTES

The LM Intrepid undocks from Command Module Yankee Clipper and begins its descent to the Moon, with Conrad and Bean aboard.

19 NOVEMBER: 110 HOURS, 32 MINUTES

Intrepid touches down with pinpoint accuracy on the designated landing spot in Oceanus Procellarum, the Ocean of Storms.

19 NOVEMBER: 115 HOURS, 10 MINUTES

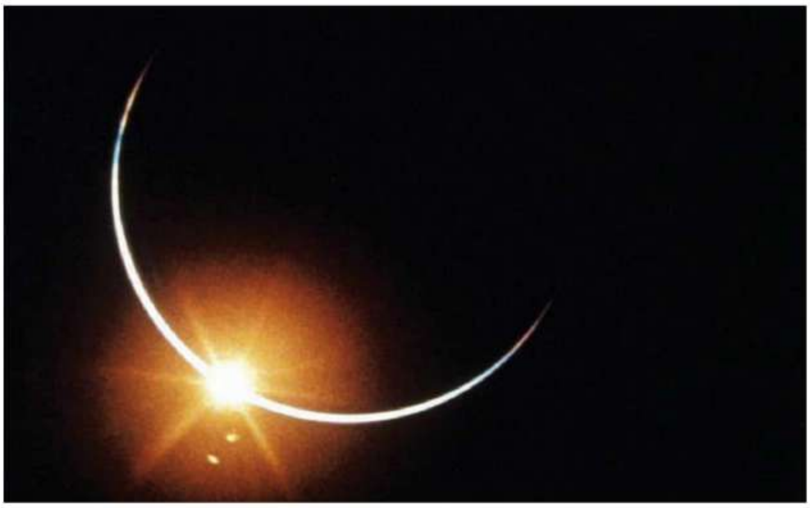
The first four-hour moonwalk begins, with Conrad's enthusiastic "Whoopee!". He and Bean then deploy an Apollo Lunar Surface Experiments Package (ALSEP) – a fuller version of the one deployed by Apollo 11.

20 NOVEMBER: 133 HOURS, 53 MINUTES

Conrad and Bean examine the three-legged Surveyor 3 robot landing craft, which launched in April 1967. The astronauts retrieve small items of equipment for return to Earth.

24 NOVEMBER: 244 HOURS, 36 MINUTES

Yankee Clipper splashes down in the Atlantic with its nose in the water, leaving the astronauts upside down for four minutes until the flotation bags right the capsule.



On the way home, the Earth moved directly between Apollo 12 and the Sun, treating the crew to this view of a solar eclipse

> “Whoopee! Man, that may have been a small step for Neil, but it's a long one for me”

▶▶ remote control to prevent any possibility of wayward pieces coming down to Earth over a populated area.

But a young NASA electrical expert, John Aaron, suspected that the lightning had scrambled the signals transmitted by Apollo, but not necessarily the actual systems inside the ship. From what he could see, the Saturn was still flying well. He suggested that the astronauts flip a particular switch on the control panel, in much the same way that an IT helpdesk advisor might suggest turning computers off and on to flush glitches out of the circuitry. The effect was miraculous, and data started streaming once more.

Yankee Clipper's systems had become confused but the Saturn rocket contained its own system, and continued to do its job flawlessly, boosting Apollo 12 into the correct orbit. After that, it was a relatively simple matter for the astronauts to get Clipper's controls back on-line.

The onboard Apollo Guidance Computer (AGC) had less power than a modern digital watch. Nevertheless it was one of the toughest computers ever invented. It was a totally hardwired system, with its software encoded as patterns of wiring, snaking in and out of the little ring-shaped magnetic cores that could not be overwritten or erased. It shrugged off the lightning scare and booted back to life without any fuss.

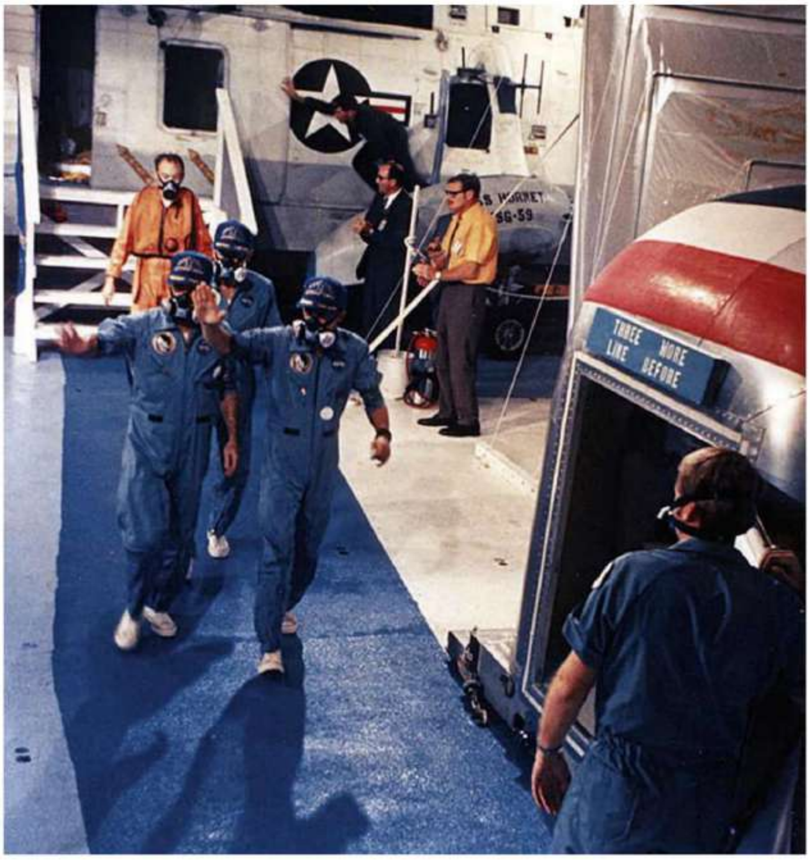
Moon landing

On 19 November, Conrad and Bean landed Intrepid with pinpoint accuracy on Oceanus Procellarum.

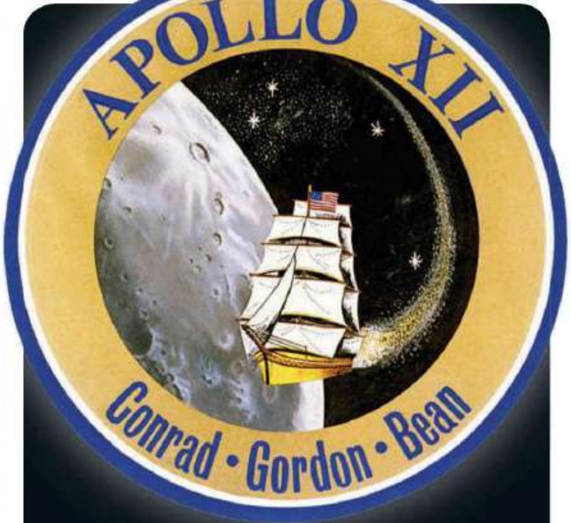
As Conrad stepped onto the lunar surface for the first of two moonwalks during the mission, he said, "Whoopee! Man, that may have been a small one for Neil, but it's a long one for me." Bean joined him, and promptly destroyed the TV camera by accidentally pointing it at the Sun. Not that it mattered. The public were less interested in NASA's latest mission now that the excitement of Apollo 11 had faded.

During the second extravehicular activity (EVA) on 20 November, Conrad and Bean reached one of their prime targets: the Surveyor 3 robotic lander, dusty but still intact after two and a half years on the Moon. They retrieved its camera for study back on Earth. NASA scientists found that earthly bacteria had survived inside it.

Apart from the scary lift-off and burned-out TV camera, Apollo 12 was a flawless mission. The press and public started to believe that flying to the Moon was a routine matter. However, NASA's next mission would change all of that.



ABOVE Safe and sound: the crew walk the short distance from the recovery helicopter to the mobile quarantine van

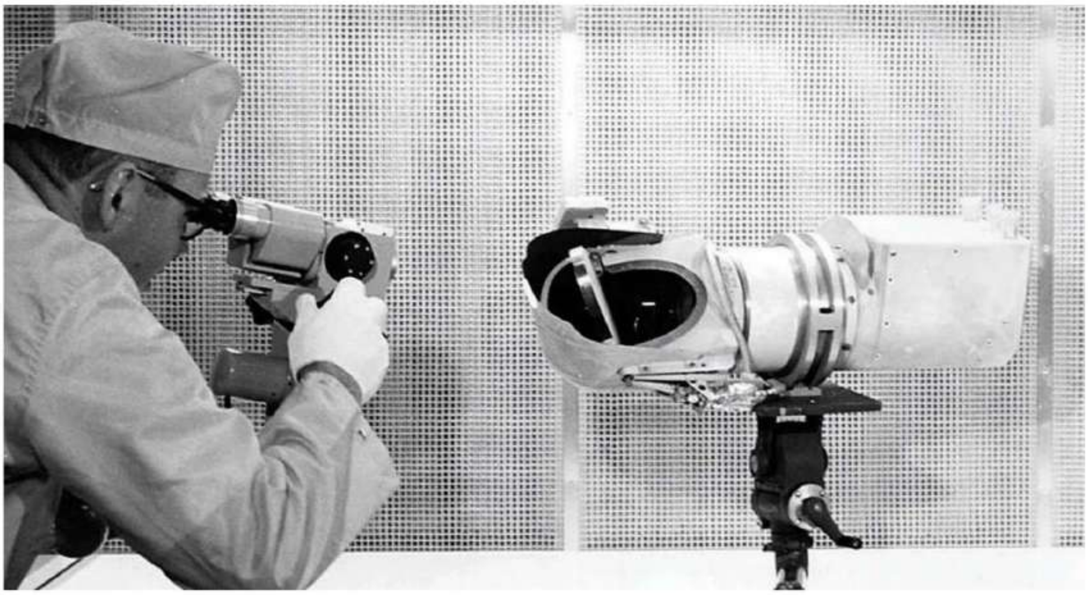


MISSION BADGE

A sailing ship took the place of a spacecraft on Apollo 12's patch thanks to the Naval background of all three crewmembers. A group of artists were brought in to sketch the exact lunar landing spot, with three stars in the sky to represent the three astronauts, and an extra one for astronaut and friend CC Williams, who had passed away.

RIGHT The quarantine van, with the crew aboard, is driven to the Lunar Receiving Laboratory in Texas

ABOVE A close up of one of the many rock samples brought back from the Moon



LEFT A scientist examines the Surveyor 3's TV camera, still intact after more than two years on the Moon

Commander Lovell in the Lunar Module, which the crew was forced to use as a lifeboat

11 April 1970

APOLLO 13

HOUSTON AVERTS DISASTER IN NASA'S FINEST HOUR

MISSION FACTS

OBJECTIVE: To land in the Fra Mauro area of the Moon. When an onboard explosion causes the mission to be aborted, its safe return is deemed a 'successful failure'.

DURATION: 5 days, 22 hours, 54 minutes, 41 seconds

COMMAND MODULE: Odyssey

LUNAR MODULE: Aquarius

For a long while, the Apollo 13 astronauts didn't know if they'd ever return to Earth

Apollo 13, launched at 13 minutes past the hour, ran into trouble on 13 April 1970, but the cause of the mission's famous 'problem' was nothing to do with unlucky numbers. In the earliest days of spacecraft construction, the electrics were modified to take different voltages than originally planned. Among thousands of components, a thermostat in an oxygen tank was overlooked. Five years later, it burned out while surrounded by liquid oxygen. Apollo 13 just happened to be the mission that suffered the consequences.

Commander Jim Lovell, Lunar Module pilot Fred Haise and Command Module pilot Jack Swigert, became household names because everybody on Earth thought they were about to die. Everybody, that is, except mission controllers in Houston, who set to work on inventing the most brilliant rescue in space history.

At first, luck had seemed to be on Apollo 13's side. Five minutes after lift-off, one of the Saturn's second stage engines failed, but the other four took up the slack, burning for 30 seconds longer than usual. "There's nothing like an interesting launch," Lovell told Mission Control. As his ship entered a perfect orbit around Earth, he added, "Houston, we're beginning to see a beautiful sunrise here."

Lovell had rounded the Moon as Command Module pilot aboard Apollo 8. Now he was eager to walk on the lunar surface. However, his dream was about to be snatched away. The first hint of trouble came 56 hours into the flight, when the spacecraft was 320,000km from Earth. Swigert radioed, "I believe we've had a problem here."

"This is Houston. Say again, please?"

Lovell confirmed that the mother ship, Odyssey, was no longer a happy one: "Houston, we've had a problem. We've had a main B bus undervolt." This was astronaut jargon for a major power failure. Haise added that "a pretty large bang" had ▶▶

> "Houston, we've had a problem. We've had a main B bus undervolt." This was astronaut jargon for a power failure

MEET THE CREW

COMMANDER
JAMES LOVELL

Born in Ohio on 25 March 1928, Lovell joined NASA in 1962. He flew on Gemini 7 with Frank Borman in December 1965 and later piloted Gemini 12 with Buzz Aldrin. Lovell was also the Command Module pilot on Apollo 8. After the Apollo missions, he was appointed consultant for Physical Fitness and Sports by President Johnson.

BACKUP CREW
COMMANDER
John Young

COMMAND MODULE PILOT
JOHN 'JACK' SWIGERT

Swigert was assigned to the backup crew for Apollo 13 and only became a crew member 72 hours before launch. He was born in Colorado on 30 August 1931 and joined NASA in 1966. Swigert left NASA in 1977 to go into politics and was elected to the House of Representatives in 1982. He died of bone cancer aged 52, before he could be sworn in.

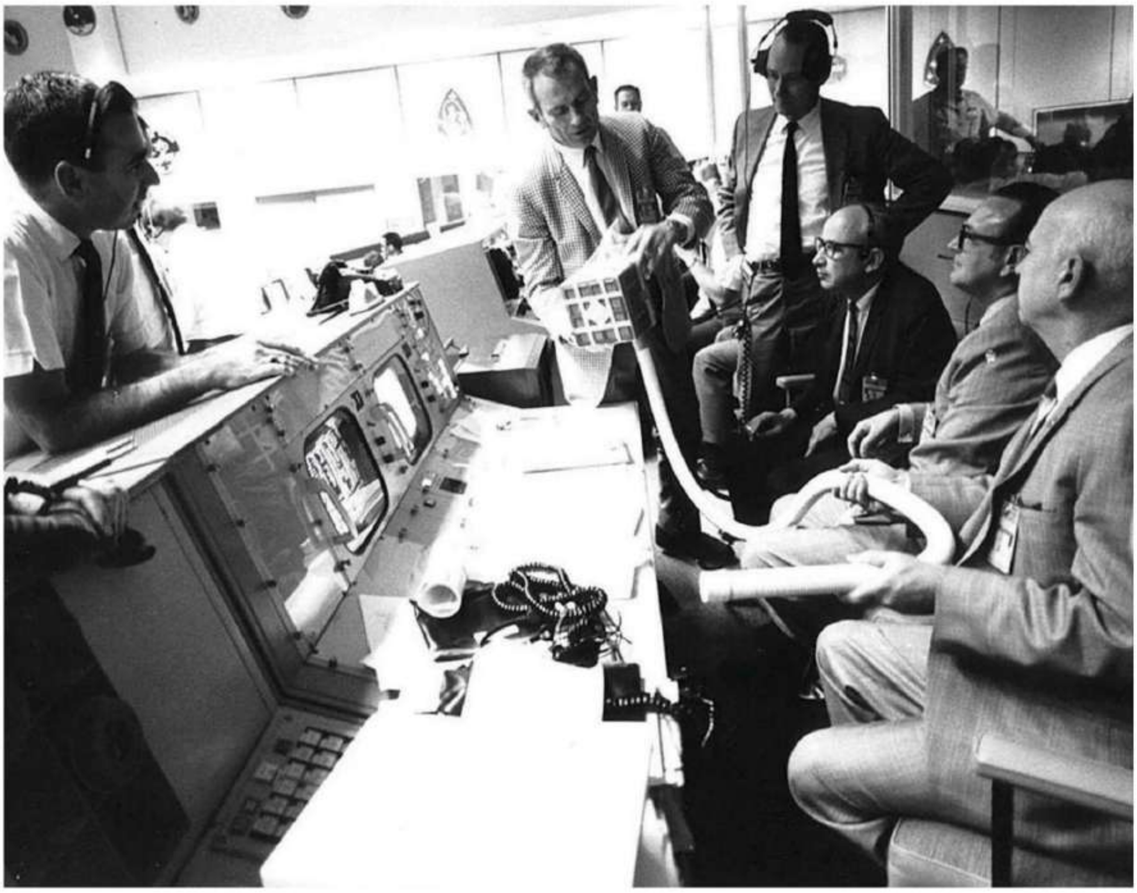
BACKUP CREW
COMMAND MODULE PILOT
Thomas 'Ken' Mattingly

LUNAR MODULE PILOT
FRED HAISE

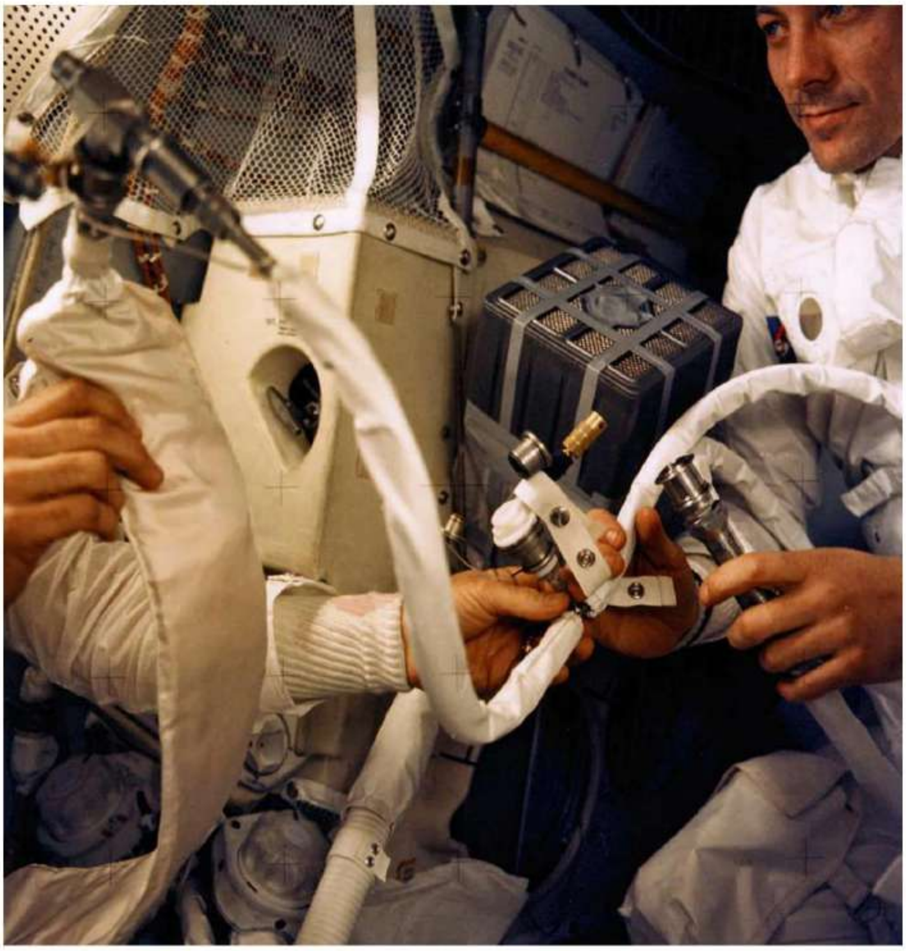
Haise was born on 14 November 1933 in Mississippi. He began his military career in 1952 as a Naval Aviation Cadet and accumulated 9,300 hours of flying time. Haise was part of the backup crew for Apollo 8, 11 and 16. In 1979, Haise left NASA to become an executive with Grumman Aerospace Corporation.

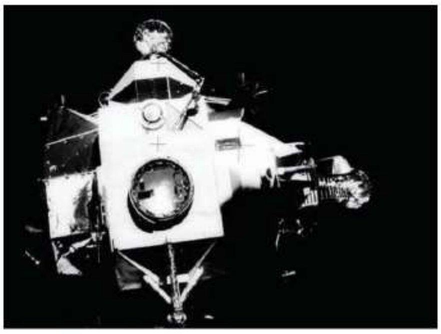
BACKUP CREW
LUNAR MODULE PILOT
Charles Duke

RIGHT Deke Slayton demonstrates how the modified canisters will purify the astronauts' air

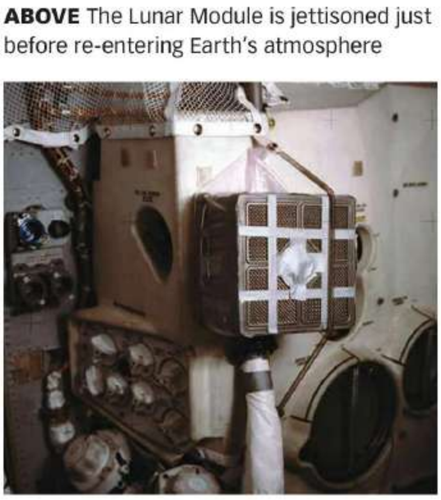


BELOW The crew get to work adapting the canisters to remove excess carbon dioxide

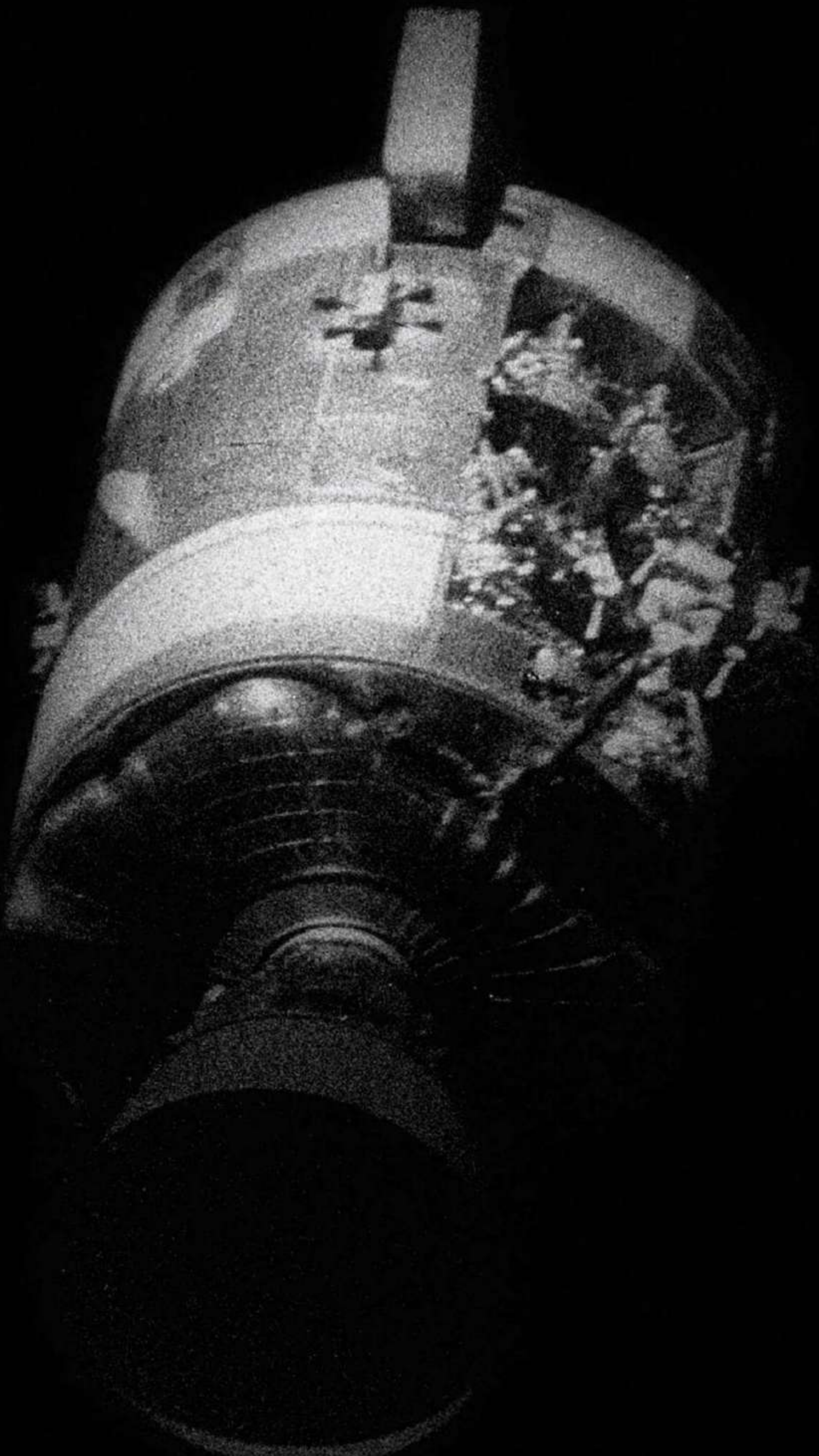




ABOVE The Lunar Module is jettisoned just before re-entering Earth's atmosphere



ABOVE The modified lithium hydroxide canisters in the Lunar Module



The damaged Service Module after separation from the spacecraft

MISSION TIMELINE

11 APRIL 1970

Apollo 13 launches at the planned time of 19:13 GMT from the Kennedy Space Center, Florida. The second-stage, centre inboard engine shuts down two minutes early, but other engines burn for longer to compensate and send Apollo 13 into orbit.

11 APRIL: 3 HOURS, 19 MINUTES

The crew successfully docks Odyssey to Aquarius and then pulls away from the spent third stage. They begin a three-day journey to the Moon.

13 APRIL: 46 HOURS, 43 MINUTES

Joe Kerwin, the capsule communicator at Mission Control, comments: "The spacecraft is in real good shape as far as we're concerned. We're bored to tears down here." It is the last time anyone complains of being bored.

14 APRIL: 55 HOURS, 53 MINUTES

Upon being asked by Mission Control to "stir up your cryo tanks" Swigert complies and the astronauts hear a "loud bang". The number 2 oxygen tank had exploded, causing number 1 tank to also fail.

14 APRIL: 61 HOURS, 29 MINUTES

A mid-course correction ignition for a free return trajectory is activated. The mission is aborted.

15 APRIL: 77 HOURS, 8 MINUTES

The crew passes behind the Moon, using its gravity to head back to Earth.

17 APRIL: 137 HOURS, 39 MINUTES

Mid-course correction ignition takes place. Over the next couple of hours, the Service Module is separated and the Command Module is powered up for the astronauts to return to.

17 APRIL: 142 HOURS, 40 MINUTES

Re-entry occurs. Communications blackout normally takes four minutes, for Apollo 13 it takes six minutes, causing great tension at Mission Control.

17 APRIL: 142 HOURS, 54 MINUTES

Apollo 13 safely splashes down in the South Pacific Ocean, much to Mission Control's relief.

This is the closest the Apollo 13 crew would get to the Moon

> “The crew had to use the Sun as an emergency guide, making swift calculations with paper and pencil”

▶▶ accompanied the warning lights on their control panels. Lovell then peered through his side window. "Houston, we are venting something out into space. It's a gas of some sort."

Emergency action

An explosion in the Service Module had destroyed the ship's oxygen supply, crippled most of its electrical power generating systems and knocked out the main engine. The astronauts switched off almost everything in the Command Module, saving what was left of its power reserves. They huddled in the Lunar Module Aquarius, trying to work out how to use its engine for an unexpected purpose. Instead of landing two men on the Moon, it would push three men and the Command and Service Modules around the Moon and back to Earth.

If any problems had shown up earlier, Apollo 13 could have flown a free return trajectory, in which gravity alone would ensure the spacecraft's safe return. But the outward phase of the voyage had appeared to be running smoothly, and the ship's course had been altered to enable Aquarius's touchdown at Fra Mauro, sacrificing the free return.

As a cloud of debris obscured the navigational telescope's view, the crew had to use the Sun as an emergency guide, making swift calculations with paper and pencil, before timing vital engine burns with a wristwatch. Five hours after the explosion, Aquarius's engine was fired to nudge the combined spacecraft back onto the free return trajectory.

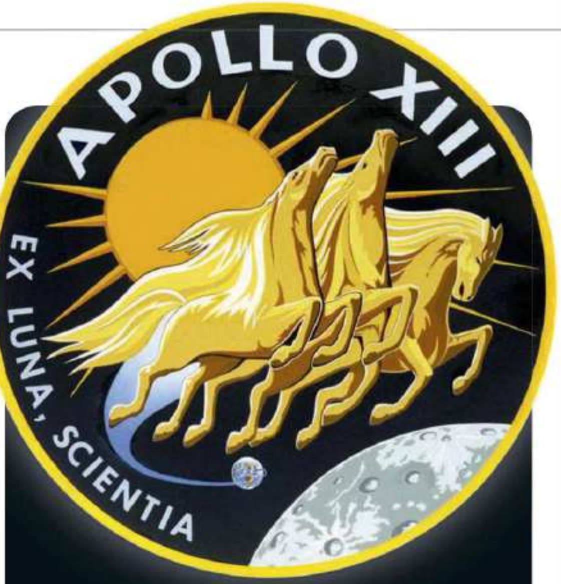
Short supply

Aquarius's life support was supposed to keep two men alive for two days. Now, three men needed those reserves for twice as long. Shortage of oxygen was less of a concern than the build up of exhaled carbon dioxide. Filters in Odyssey and Aquarius were shaped differently. Mission Control had to invent a solution using space suit hoses, tape and document covers. Step by step, they relayed instructions to the cold and exhausted astronauts.

Just before re-entry, the Service Module was discarded. "There's one whole side of that spacecraft missing," Lovell exclaimed. Incredibly, everything else still worked. Lovell may have been disappointed not to reach the lunar surface, but his 'failed' mission is regarded as one of NASA's finest hours. ❸

RIGHT Odyssey heads for splashdown in the Pacific Ocean near Samoa

BELOW Everyone at Mission Control celebrates the safe return of the crew



MISSION BADGE

Jim Lovell was becoming quite handy with designing patches, and found inspiration for Apollo 13 from the mythical god Apollo and his chariot of horses. The main design of the patch came from a mural of a herd running in the wild – Tom Hanks bought the painting and gave it to Lovell as a gift when he portrayed him in Apollo 13. The Latin reads 'From the Moon, knowledge'.

ABOVE (l–r) Haise, Lovell, President Nixon and Swigert honour the American flag

LEFT President Nixon presents the Presidential Medal of Freedom – the highest civilian honour – to the Apollo 13 Mission Operations Team

Al Shepard practises pulling lunar equipment under the 1/6 gravity that they will experience on the Moon

31 January 1971

APOLLO 14

THE THIRD SUCCESSFUL LANDING – AND TIME FOR A GAME OF GOLF

MISSION FACTS

OBJECTIVE: To explore the Fra Mauro area of the Moon and collect samples of the Moon's surface. Apollo 14 would also relay the first colour images from the Moon's surface.

DURATION: 9 days, 2 minutes

LUNAR SURFACE TIME: 1 day, 9 hours, 30 minutes, 29 seconds

COMMAND MODULE: Kitty Hawk

LUNAR MODULE: Antares

After a 40-minute delay waiting for a storm to pass, Apollo 14 finally blasts off at 21:03 GMT

After the drama of Apollo 13, it was nine months before NASA launched another Moon shot.

On the afternoon of 31 January 1971, Apollo 14's Saturn V stood fuming on its pad in Florida. On board were mission commander Alan Shepard, making his second spaceflight since becoming America's first man in space (in 1961); and two first-timers: Lunar Module (LM) pilot Ed Mitchell and Command Module (CM) pilot Stuart Roosa.

Dark storm clouds passed overhead and the launch was delayed by 40 minutes, but Apollo 14 eventually got under way, much to Shepard's relief. Problems with his inner ear had grounded him throughout most of the '60s, but he'd used those years constructively. He'd become the hard-driving chief of NASA's Astronaut Office in Houston and put himself through countless medical checks to regain his flight status at the grand old age – for an Apollo astronaut – of 47. He didn't need anything else blocking his path to the Moon.

Unfortunately, just three hours into the mission, it looked like Shepard might have his hopes dashed after all. Try as he might, Roosa couldn't get Kitty Hawk, the CM, to dock with LM Antares. Five times Roosa eased the tip of Kitty Hawk onto the roof of Antares and five times the two ships slid apart.

Mission Control advised him to dock again and this time, instead of shutting his thrusters off, to keep firing them for a while so the docking probe on Kitty Hawk's tip would really ram home. On this sixth attempt, everything worked. Later on, when the crew opened the hatches and looked at all the mechanisms, nothing seemed wrong with them.

> “Try as he might, Roosa couldn't get Kitty Hawk, the Command Module, to dock with Lunar Module Antares”

Touchdown

Yet more drama was to come upon reaching lunar orbit. After separating from Kitty Hawk, Antares – with Shepard and Mitchell aboard – had

▶▶

MEET THE CREW

COMMANDER
ALAN SHEPARD

Born on 18 November 1923 in New Hampshire, Shepard started off in the Navy. He was one of the Mercury Seven and on 5 May 1961 he made America's first manned trip into space. Grounded due to inner ear problems, he led NASA's Astronaut Office before commanding Apollo 14. He died on 21 July 1998, aged 74.

BACKUP CREW
COMMANDER
Eugene Cernan

COMMAND MODULE PILOT
STUART ROOSA

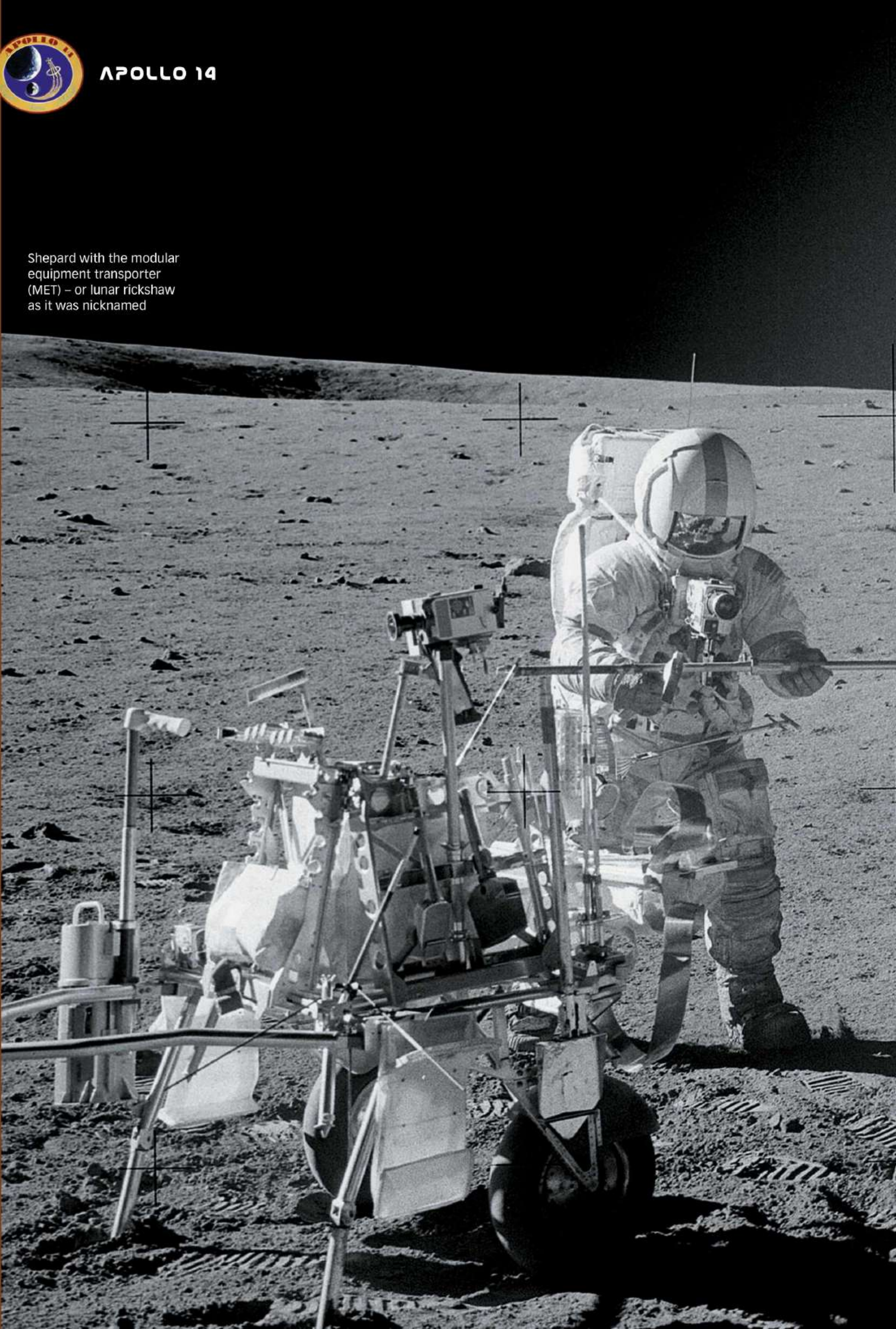
Stuart Roosa was born on 16 August 1933 in Colorado. Prior to joining NASA in 1966, Roosa worked for the Forest Service as a firefighter and later served as a test pilot. Apollo 14 was Roosa's only space flight, but he was backup for Apollos 16 and 17, and then went on to work on development of the Space Shuttle. He died on 12 December 1994, aged 61.

BACKUP CREW
COMMAND MODULE PILOT
Ronald Evans

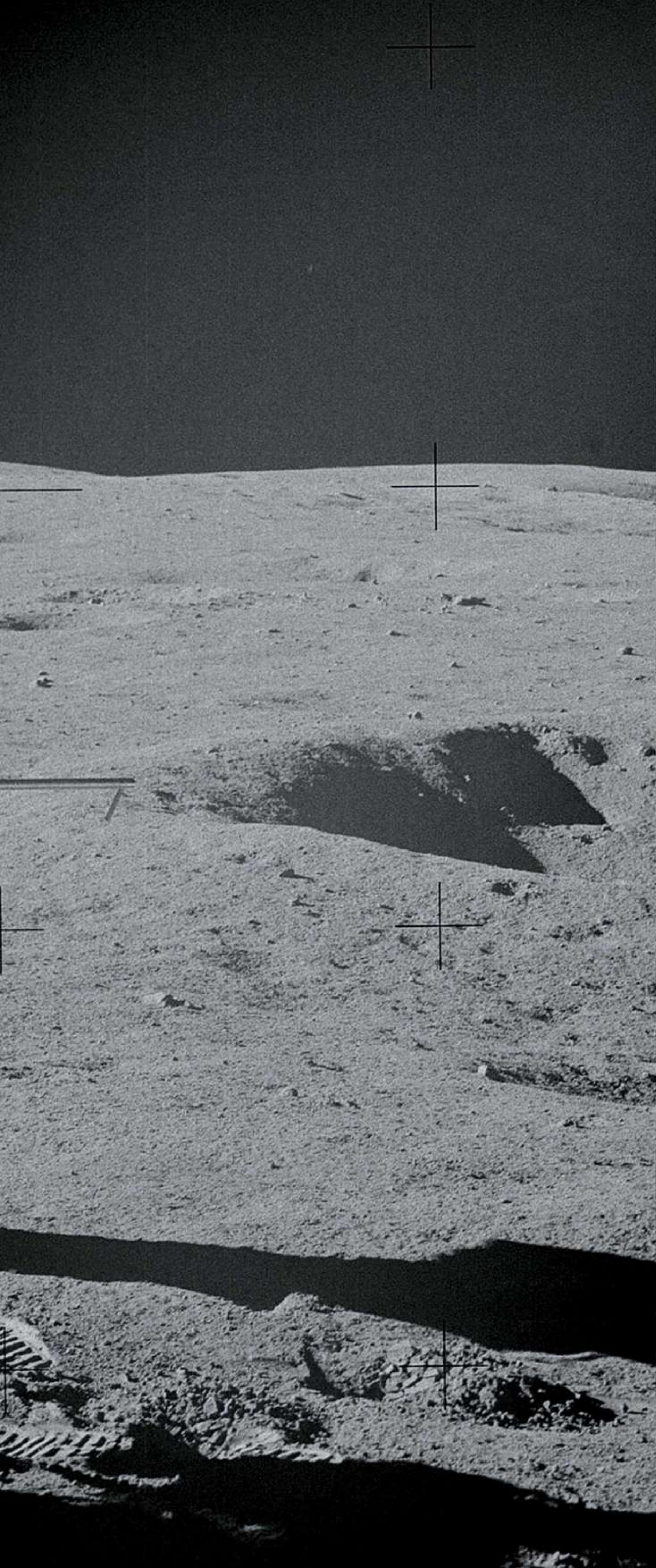
LUNAR MODULE PILOT
EDGAR MITCHELL

Texan Mitchell was born on 17 September 1930 and studied aeronautics at MIT. He flew for the Navy before joining NASA in 1966. Mitchell was profoundly affected by his experiences in space and in 1973 he founded the Institute of Noetic Sciences to research consciousness and its relationship to the Universe. He died in 2016, aged 85.

BACKUP CREW
LUNAR MODULE PILOT
Joe Engle



Shepard with the modular equipment transporter (MET) – or lunar rickshaw as it was nicknamed



Shepard (foreground) and Mitchell in the Lunar Module Simulator during pre-flight training

The calm before the storm: the Apollo 14 crew and ground staff enjoy a pre-launch breakfast

Shepard stands next to a large boulder on the Fra Mauro Highlands

Shreds of gold insulation foil scatter as Antares blasts off from the lunar surface

MISSION TIMELINE

31 JANUARY 1971
Countdown delays caused by bad weather fail to spoil a perfect launch for Apollo 14 atop its giant Saturn V rocket. It gets off the ground at 21:03 GMT.

31 JANUARY: 11 MINUTES, 50 SECONDS
The mission enters Earth's orbit and the single engine in the upper S-IVB stage is shut down.

1 FEBRUARY: 4 HOURS, 56 MINUTES
After nearly two hours of frustration, Roosa finally gets Command Module Kitty Hawk to dock with Lunar Module Antares on the sixth attempt.

4 FEBRUARY: 81 HOURS, 56 MINUTES
Apollo 14 enters lunar orbit.

4 FEBRUARY: 82 HOURS, 38 MINUTES
As planned, the S-IVB stage, discarded three days earlier, hits the Moon. Apollo 12's seismometer, left behind on the Moon in 1969, registers the impact.

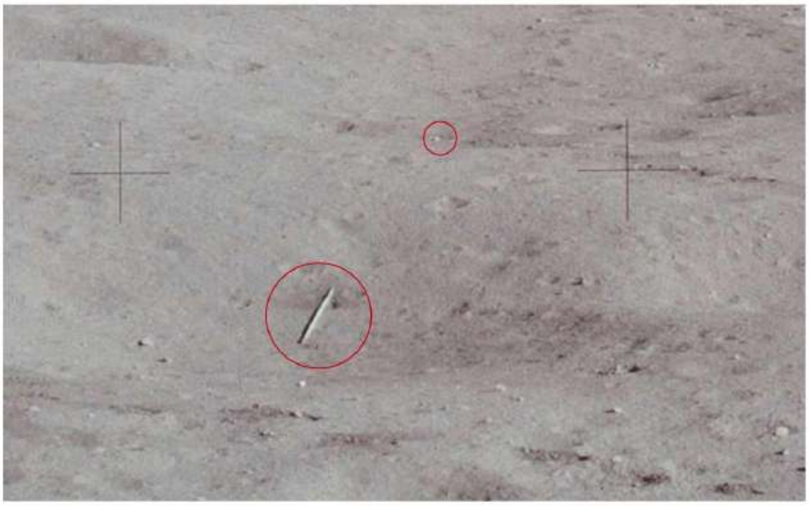
5 FEBRUARY: 108 HOURS, 15 MINUTES
The astronauts touch down on the Moon at the designated Fra Mauro site.

5 FEBRUARY: 113 HOURS, 39 MINUTES
Shepard and Mitchell open the Lunar Module's forward hatch and embark on the first of two planned moonwalks.

6 FEBRUARY: 131 HOURS, 8 MINUTES
The crew depressurises Antares in preparation for the second moonwalk. Shepard and Mitchell collect 42kg of rock samples.

6 FEBRUARY: 141 HOURS, 45 MINUTES
The Lunar Module Antares fires its ascent engine and climbs away from the lunar surface to rejoin Kitty Hawk in orbit.

9 FEBRUARY: 216 HOURS, 2 MINUTES
Kitty Hawk splashes down in the Pacific Ocean to conclude the fairly smooth mission. The prime recovery ship is USS *New Orleans*.



This image shows Shepard's golf ball and a lunar scoop handle that Mitchell threw, pretending it was a javelin

> “Shepard then indulged in his favourite sport, becoming the first person in history to play golf on the Moon”

▶▶ some unsettling moments. The guidance computer indicated that an automatic 'abort' might be triggered at any moment. In a tense re-run of similar false warnings during Apollo 11's descent, mission controllers gambled correctly that the computer was giving false readings, possibly because of a loose switch.

Ancient impact

Antares finally touched down in the Fra Mauro Highlands, the area that was to have been explored by Apollo 13. The terrain was littered with debris from the ancient impact that created the Imbrium Basin. Heat and pressure had fused countless rock fragments into new rocks, called breccias. In some cases, the breccias themselves were formed from even earlier breccias. Apollo 14's moonwalkers confirmed Fra Mauro's violent history.

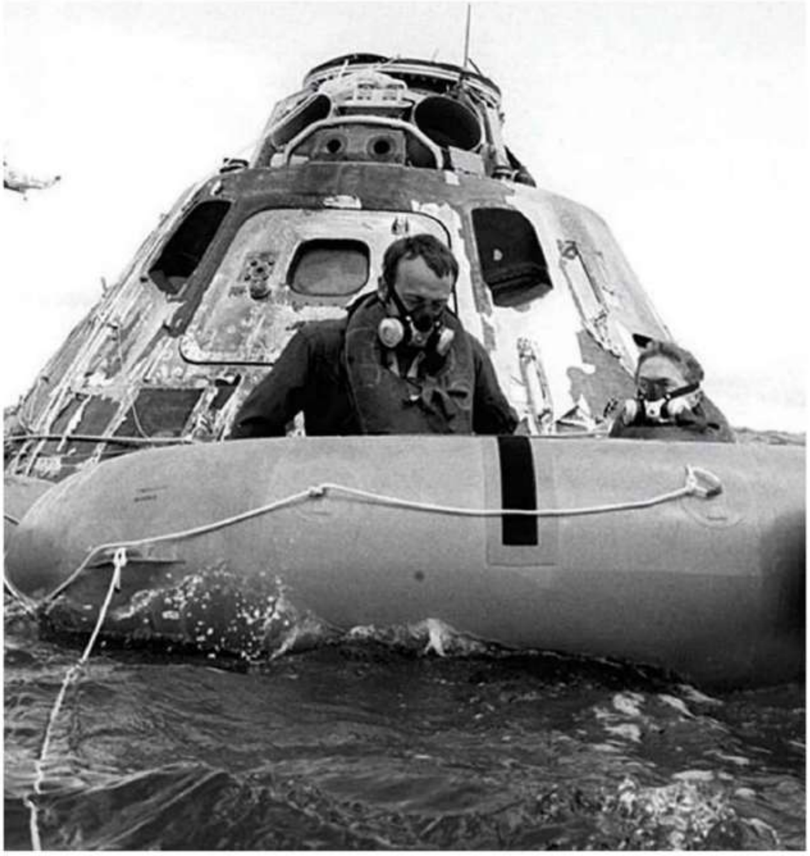
Shepard and Mitchell conducted two moonwalks totalling more than nine hours using NASA's first wheeled lunar equipment – a collapsible handcart loaded with tools and cameras, nicknamed the lunar rickshaw. Their only disappointment was their inability to reach Cone crater, an interesting target that had seemed accessible from the maps of the landing site. Unfortunately, the slopes leading up to its edge were too steep for the astronauts to safely attempt to climb.

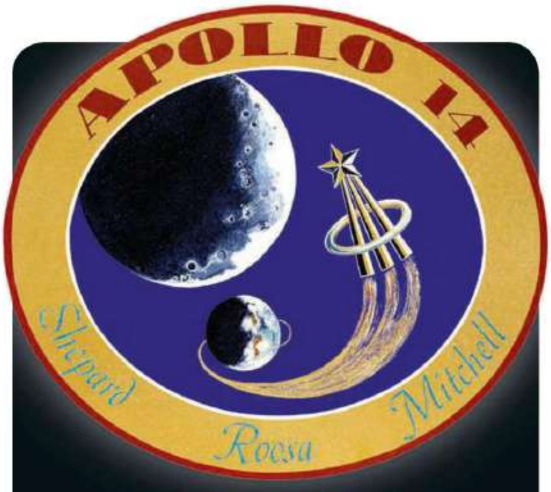
A few minutes before clambering back up the LM's ladder for the last time, Shepard gave Mission Control a surprise. Wielding the handle from one of the rock sampling tools, he announced: “It just so happens to have a genuine six iron on the bottom of it. In my left hand, I have a little white pellet that's familiar to millions of Americans. I'll drop it down.”

He then indulged in his favourite sport, and in doing so became the first person to play golf on the Moon, albeit one-handed, as “the suit is so stiff, I can't do this with two hands, but I'm going to try a little sand-trap shot here”.

His first shot simply gouged out a puff of lunar dust. Mitchell goaded him: “You got more dirt than ball that time.” And his second attempt wasn't much good either. Back at Mission Control, Apollo 13 veteran Fred Haise in the capsule communicator seat also lost no time in having a gentle dig at Shepard: “That looked like a slice to me, Al.” The third shot was better. “Here we go. Straight as a die,” Shepard said. “Miles and miles and miles.”

Actually, the ball travelled no more than about 20 metres, but at long last, Shepard, the first American in space, was happy.





MISSION BADGE

The coveted gold astronaut pin – which was only given to those who had made a successful trip into space – replaced the traditional spacecraft on this patch. Since its use on the Apollo 14 patch, the gold pin has become a popular addition to spaceflight patches, appearing on at least 31 others. The design is often criticised for showing outer space as bright blue instead of a more recognisable black, and some say that the names of the crew almost get lost in the gold border.

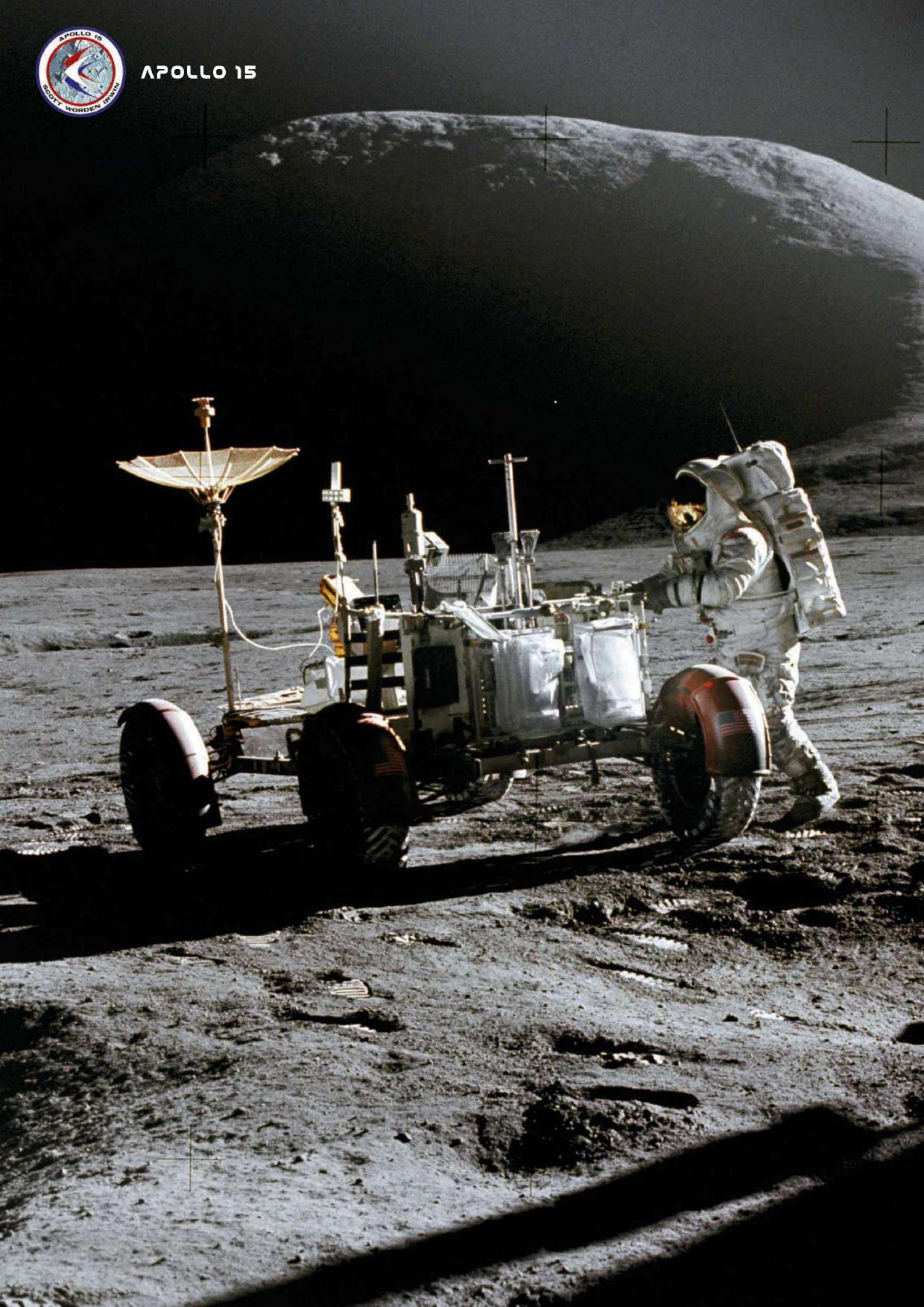
ABOVE Following a safe landing, Shepard and Roosa await pickup by the rescue helicopter

AUTHORIZED PERSONNEL ONLY

RIGHT (l–r) Roosa, Shepard and Mitchell greet the press from their quarantine van

ABOVE Scientists experiment on the lunar samples in a Sterile Nitrogen Atmospheric Processing laboratory

LEFT The crew show off some of the larger rocks that they brought back for testing



Jim Irwin prepares the
Lunar Roving Vehicle for
the first drive on the Moon

26 July 1971

APOLLO 15

A LONG STAY AND THE FIRST DRIVE ON THE MOON

MISSION FACTS

OBJECTIVE: Equipped for a longer stay on the Moon, the main aim was to conduct extensive scientific experiments. This was also the first mission to test out the Lunar Roving Vehicle.

DURATION: 12 days, 7 hours, 12 minutes, 53 seconds

LUNAR SURFACE TIME: 2 days, 18 hours, 54 minutes, 54 seconds

COMMAND MODULE: Endeavour

LUNAR MODULE: Falcon

Dave Scott salutes well-wishers as he leads the crew to the launch pad

Apollo 15 was a very different expedition from the three Moon landings that preceded it. The first of the advanced 'J-class' missions, this spacecraft carried an extra 1,800kg of fuel and apparatus. This included sufficient supplies for a full three-day stay on the lunar surface and a host of new equipment. There was a suite of imagers hosted on the Endeavour Command Module (CM) to survey the Moon from orbit, a 'subsatellite' to be launched into lunar orbit, and the first Lunar Roving Vehicle (LRV), folded to the side of the Falcon Lunar Module (LM). Redesigned space suits had extra joints to allow their astronauts to sit in the LRV and to permit multiple seven-hour extravehicular activities (EVAs). The aim was to boost Apollo's scientific return at a time when the programme was drawing increased criticism.

By now, Apollo had acquired competitors in the shape of unmanned Soviet probes. The previous year, Luna 16 had returned lunar soil to Earth and the Lunokhod 1 rover had traversed the Moon's surface. If robots could do so much, were manned missions still worth the cost and risk?

Apollo 15 had a lot to prove – something its competitive, three-man crew eagerly embraced. Commander Dave Scott, along with LM pilot Jim Irwin and CM pilot Al Worden decided they could still compete for a prominent piece of scientific history. Although they were all pilots by training, the astronauts did their best to become expert geologists as well, alternating classroom instruction with regular field trips.

> “The first of the advanced 'J-class' missions, Apollo 15 carried an extra 1,800kg of supplies”

Meanwhile, scientists scoured the Moon to find a site with sufficiently varied features to make it worthy of a long weekend stay. They settled on the highs and lows surrounding Hadley Rille – a 400m-deep valley carved out by an ancient magma stream running along the foothills of the lunar Apennine Mountains.

▶▶

MEET THE CREW

COMMANDER
DAVID SCOTT

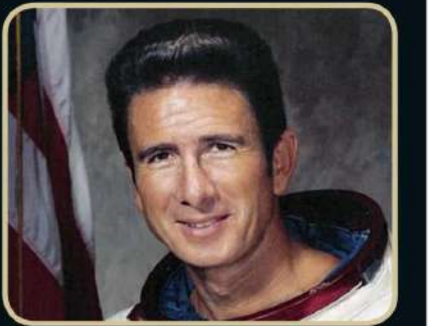
Dave Scott followed in his US Air Force father's footsteps. Born on 6 June 1932, Scott was the first of NASA's third group of astronauts to reach space – he flew on Gemini 8 and then served as Command Module pilot on Apollo 9 in March 1969. He was a consultant on the *Apollo 13* movie and *From the Earth to the Moon* TV series.

BACKUP CREW
COMMANDER
Richard Gordon

COMMAND MODULE PILOT
ALFRED WORDEN

Born in Michigan on 7 February 1932, Al Worden graduated from West Point and the RAF's Empire Test Pilots' School. Like his fellow Apollo 15 crew members, Worden's astronaut career was ended by the 'stamp affair' – the crew took stamps to the Moon to sell afterwards. In 1975 he left NASA for the aerospace industry and ran unsuccessfully for congress in 1982.

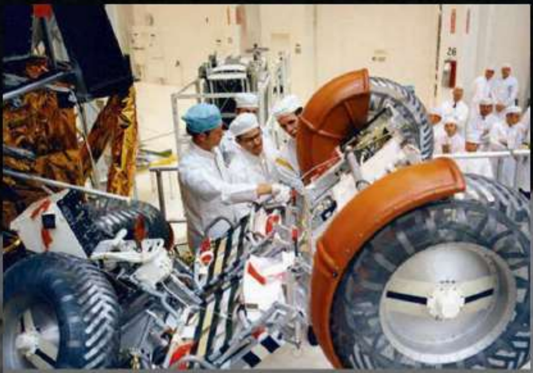
BACKUP CREW
COMMAND MODULE PILOT
Vance Brand



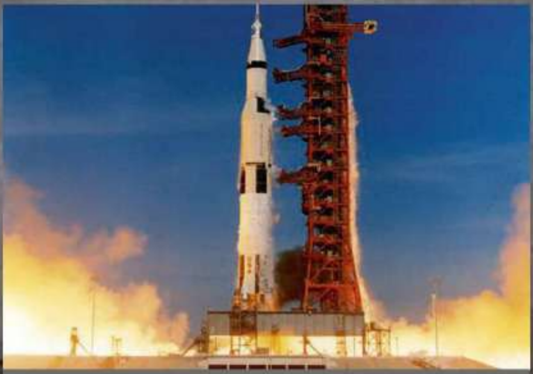
LUNAR MODULE PILOT
JAMES IRWIN

Hailing from Pittsburgh and born on 17 March 1930, Jim Irwin became a US Air Force test pilot. Ten years prior to Apollo 15, he almost lost a leg after a serious air crash. The mission made him the eighth person to walk on the Moon, though he suffered serious heart problems on his return. He died on 8 August 1991, aged 61.

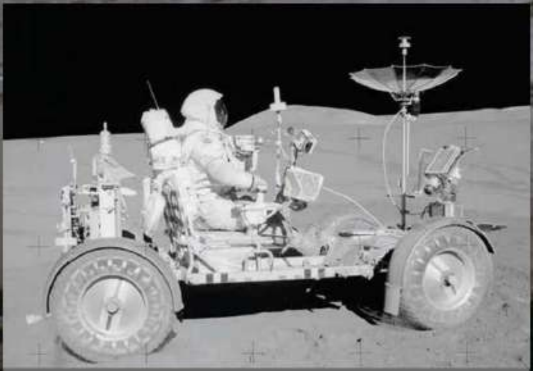
BACKUP CREW
LUNAR MODULE PILOT
Harrison Schmitt



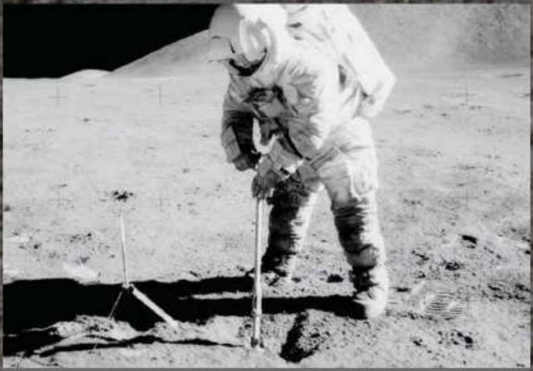
The crew and technicians examine the LRV while it's attached to Falcon



The swing arms on the tower release the spaceship as the Saturn V rocket rises



Scott takes the driving seat in the LRV for a first spin on the Moon



Irwin uses a scoop to collect samples at the base of Mount Hadley

UNITED STATES

The Lunar Module Falcon lands at an angle, which makes unfolding the Lunar Roving Vehicle more difficult

MISSION TIMELINE

26 JULY 1971
On a clear and bright day, Apollo 15 launches at 13:34 GMT, just 187 milliseconds off schedule.

30 JULY: 104 HOURS, 42 MINUTES
The Lunar Module touches down hard and blind. Falcon tilts 10 degrees with one foot in a crater.

30 JULY: 106 HOURS, 38 MINUTES
While in lunar orbit in Endeavour, Worden spots Falcon on the Moon's surface.

31 JULY: 106 HOURS, 42 MINUTES
Scott performs a 33-minute 'stand-up' EVA, sticking his head out of Falcon.

31 JULY: 119 HOURS, 39 MINUTES
The first extravehicular activity (EVA) proper begins. The Lunar Roving Vehicle (LRV) is taken out for a 10.3km drive to St George crater.

1 AUGUST: 142 HOURS, 14 MINUTES
For the second EVA, Scott and Irwin head to the Apennines and discover the 'Genesis Rock' on the rim of Spur crater.

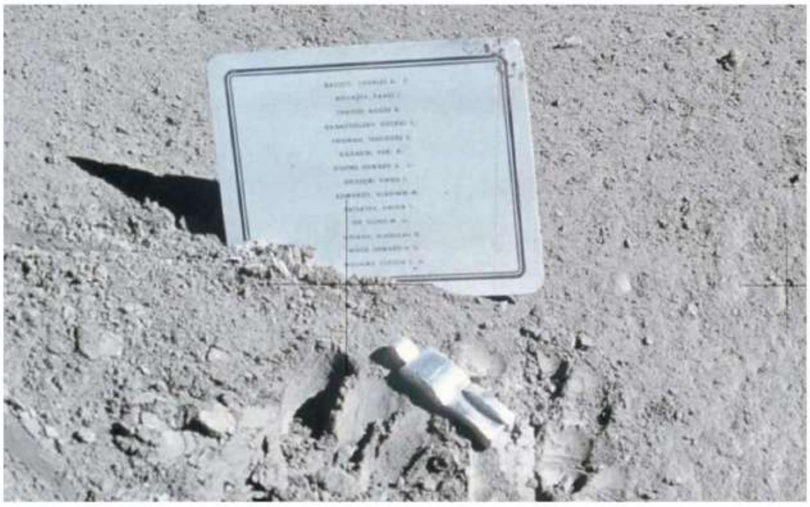
2 AUGUST: 163 HOURS, 27 MINUTES
During the third EVA, the crew traverse west to Scarp crater and northwest along the edge of the Hadley Rille, recovering samples. Scott places the Fallen Astronaut memorial.

2 AUGUST: 171 HOURS, 37 MINUTES
Falcon lifts off from the lunar surface. Scott and Irwin have collected 76.6kg of samples. For the first time, the lunar lift-off was seen on Earth via the LRV's TV camera.

4 AUGUST: 222 HOURS, 39 MINUTES
Endeavour deploys the first 'subsatellite' into orbit.

5 AUGUST: 241 DAYS, 57 MINUTES
Worden performs the first deep-space EVA on the way back to Earth, retrieving film cartridges.

7 AUGUST: 295 HOURS, 11 MINUTES
With one parachute out of action, Falcon experiences a harder splashdown than normal. The crew is picked up by USS *Okinawa*.



A commemorative plaque left behind in memory of 14 NASA astronauts and USSR cosmonauts who had died. The figure represents a fallen astronaut

> “The Sun-drenched Apennines were striking, their summits gently rounded due to countless micrometeorite falls”

▶▶ Hadley Rille was the most northerly of all Apollo destinations. Getting there required more fuel and entailed extra challenges. The LM had to come in on a steeper 26° approach compared to the standard 15°, just to clear 4.5km-high mountain peaks, while still landing on the right side of the rille. It was also unknown territory compared to previous destinations, because the best available satellite images only showed features 20m in scale or larger. Scott found himself losing orientation during approach, worrying that he might land west of the 1km-wide valley, or even in it.

Upon landing he stuck his head out of the Falcon to survey the terrain and check its suitability for driving. The Sun-drenched Apennines were striking, their summits gently rounded due to countless micrometeorite falls.

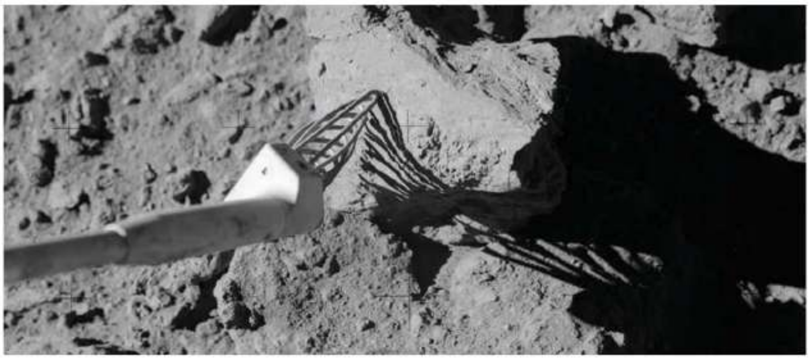
The first full EVA occurred the next day, Scott declaring: "As I stand out here in the wonders of the unknown at Hadley, I sort of realise there's a fundamental truth to our nature: man must explore." The first thing he and Irwin discovered was that the LM had landed with a 10° tilt, complicating the supposedly routine LRV unfolding. This tilt may also have contributed to problems filling their life-support packs – Irwin ended up with no access to drinking water during the EVAs.

Moon drive

The pair drove off bumpily at a top speed of 12km/h to the 10km-distant St George crater. Then, the following day, they took the high road to the Apennine foothills, searching for rocks thrown up by the catastrophic impact that formed the Imbrium Basin (the Apennines form its eastern verge). Their geology training guided them to the 4-billion-year-old so-called 'Genesis Rock', which pre-dated the Basin altogether.

The final day's EVA headed to the Hadley Rille itself. It had appeared to have treacherous cliffs in satellite images, but in reality it turned out to comprise relatively gentle 25° slopes.

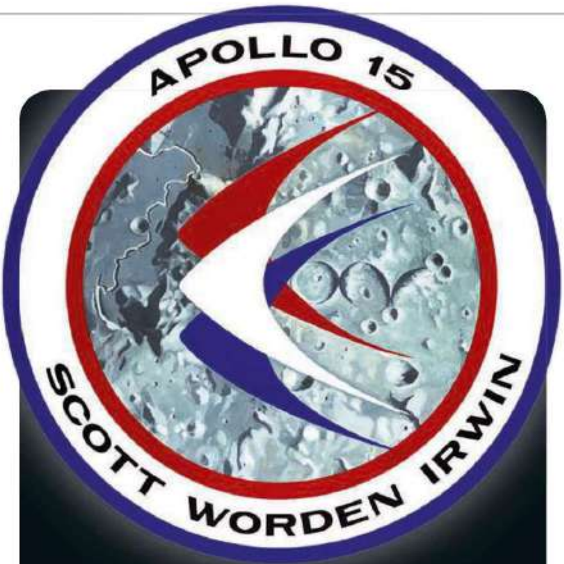
But this bounty came at a cost. Having re-docked with Endeavour, Irwin developed irregular heart rhythms, possibly triggered by his dehydration. "It's serious," said flight surgeon Charles Berry. "If he were on Earth I'd have him in ICU getting treated for a heart attack." Irwin made it home without further incident but, a few months later, he had the first of the heart attacks that eventually killed him in 1991. It was a sad footnote to the Apollo programme – Irwin was the first, and the youngest, of the 12 moonwalkers to die. Ⓢ



ABOVE A sample boulder with slickensides (smooth surfaces) is collected using tongs

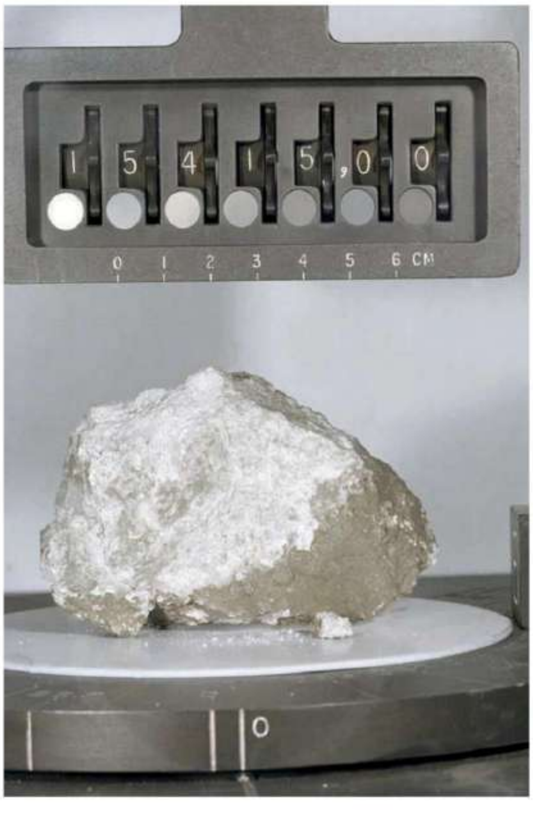
LEFT The solar wind measuring device – part of the Apollo Lunar Surface Experiments Package (ALSEP)

BELOW A Navy diver opens the hatch on Endeavour to welcome the crew back to Earth

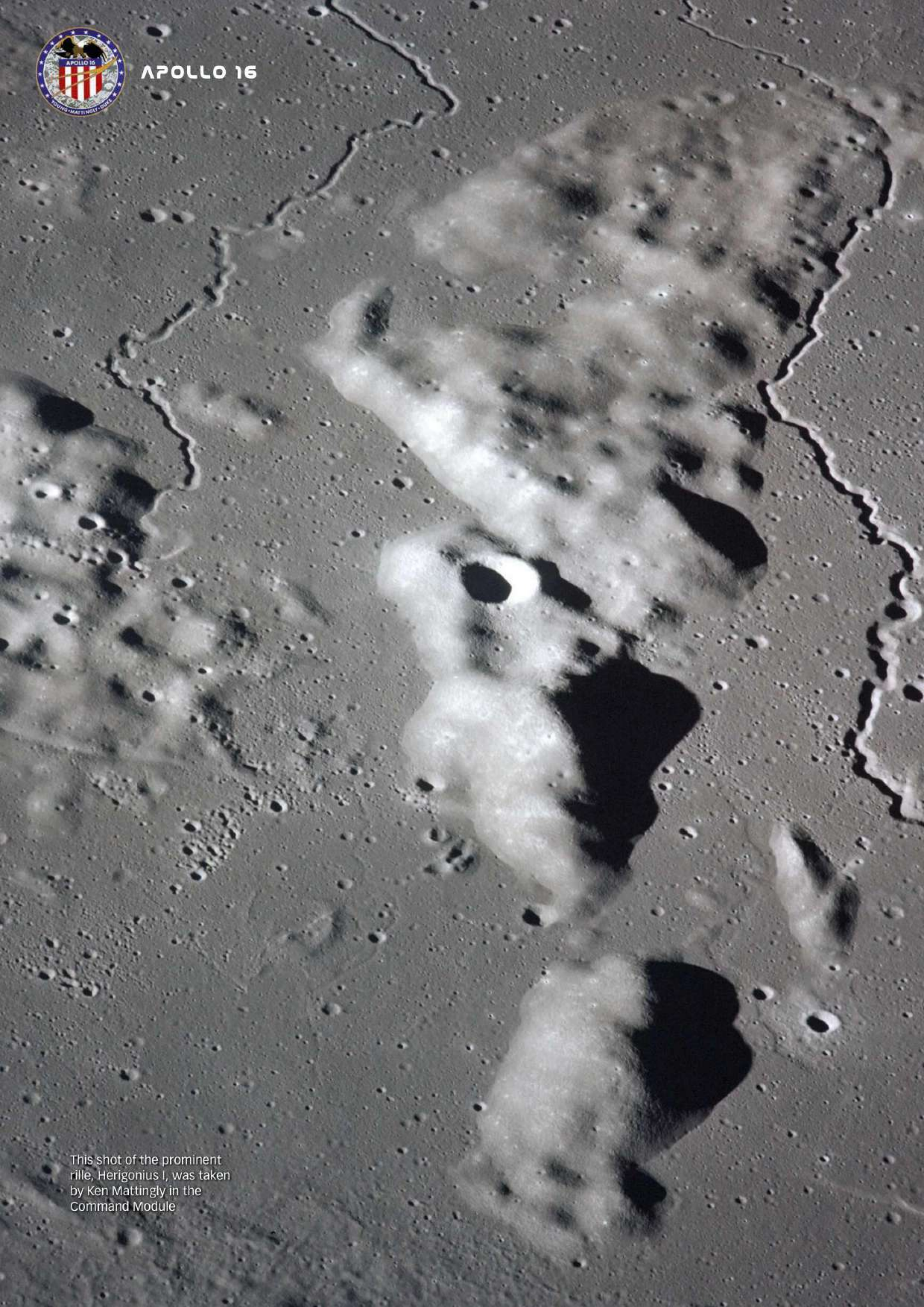


MISSION BADGE

Famous clothes designer Emilio Pucci designed Apollo 15's patch. He was a former torpedo bomber and also had a doctorate in political science. The three birds represent the three astronauts on the mission, but NASA changed Pucci's flamboyant greens and purples to a more patriotic red, white and blue. A crater formation also shows the mission number in Roman numerals.



ABOVE A sample of the Genesis Rock collected by the astronauts during their second moonwalk. Scientists concluded it to be white anorthositic rock approximately 4 billion years old



This shot of the prominent rille, Herigonius I, was taken by Ken Mattingly in the Command Module

16 April 1972

APOLLO 16

A MISSION THAT CHANGES OUR UNDERSTANDING OF LUNAR GEOLOGY

MISSION FACTS

OBJECTIVE: To inspect, survey and collect sample materials at the landing site in the Descartes region. The crew also had to conduct further in-flight tasks and photograph areas of the Moon while in lunar orbit.

DURATION: 11 days, 1 hour, 51 minutes, 5 seconds

LUNAR SURFACE TIME: 2 days, 23 hours, 2 minutes, 13 seconds

COMMAND MODULE: Casper

LUNAR MODULE: Orion

The astronauts look back to the Earth as they approach the dark side of the Moon

Apollo 16 launched for the Moon on 16 April 1972. It was the second mission to carry a Lunar Roving Vehicle (LRV), stored in the Lunar Module's (LM) descent stage. John Young was mission commander, with Charles Duke piloting the LM Orion and Ken Mattingly flying the Command Module (CM) Casper.

Shortly after Orion undocked from Casper, the two spacecraft drifted in formation in lunar orbit, undergoing final checks before Orion began its descent. Mattingly prepared to fire his main engine and push Casper into a suitable orbit. As Mattingly checked the backup control circuits for steering the Service Module's main engine, the entire spacecraft shuddered. "I be a sorry bird," he told Mission Control, clearly concerned that the landing attempt was endangered.

The two spacecraft drifted together for six hours until Mission Control decided that Mattingly could fire his engine on the primary circuits. It worked and Orion's solo voyage resumed. Young and Duke had been awake for 13 arduous hours by the time they landed in the Descartes Highlands and, despite their excitement, had to begin their lunar visit with a meal and an emergency nap.

The first of three extravehicular activities (EVAs) was devoted mainly to unpacking the LRV and deploying the Apollo Lunar Surface Experiment Package (ALSEP). Young had trouble with the Heat Flow Experiment, two probes pushed into the topsoil to measure the warmth from the Moon. As he walked away, a cable snagged on his boot and was wrenched loose, causing irreparable damage to the experiment. He was more successful with the explosive 'thumper', a rod with a cylinder shaped like a tin of beans at its end and loaded with explosive charges, used as part of an experiment to collect seismic data to determine the structure of the Moon's crust. He fired 19 charges against marked points on a 90m sensor cable trailing on the surface, creating miniature seismic shocks. ▶▶

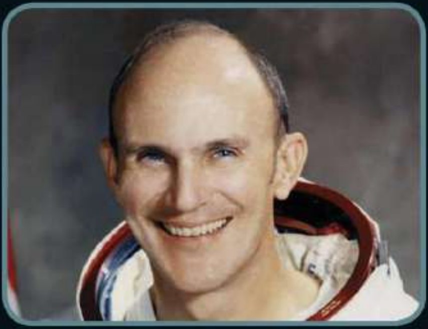
> “As Mattingly checked the backup control circuits for steering the main engine, the entire spacecraft shuddered”

MEET THE CREW

COMMANDER
JOHN YOUNG

San Franciscan Young was born on 24 September 1930. A test pilot with an aeronautical engineering degree from Georgia Institute of Technology, he joined NASA in 1962. He is the only person to fly twice in three different spacecraft: Gemini, Apollo and the Shuttle. He retired from NASA in 2004 and died in 2018.

BACKUP CREW
COMMANDER
Fred Haise



COMMAND MODULE PILOT
THOMAS 'KEN' MATTINGLY

'Ken' Mattingly was born in Chicago on 17 March 1936 and studied aeronautical engineering at Auburn University, Alabama. He attended Air Force Aerospace Research Pilot School before joining NASA in 1966. He was due to fly on Apollo 13, but a measles scare grounded him. After Apollo, he commanded Space Shuttle missions in 1982 and 1985.

BACKUP CREW
COMMAND MODULE PILOT
Stuart Roosa

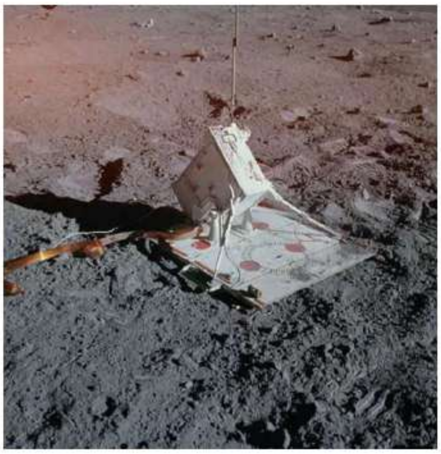
LUNAR MODULE PILOT
CHARLES DUKE

Born on 3 October 1935 in North Carolina, Duke studied at the US Naval Academy before becoming an Air Force pilot and joining NASA in 1966. He was a capsule communicator for Apollo 11 and backup for Apollo 13. When Apollo was retired in the mid-1970s, he retired from space too and began a career in business.

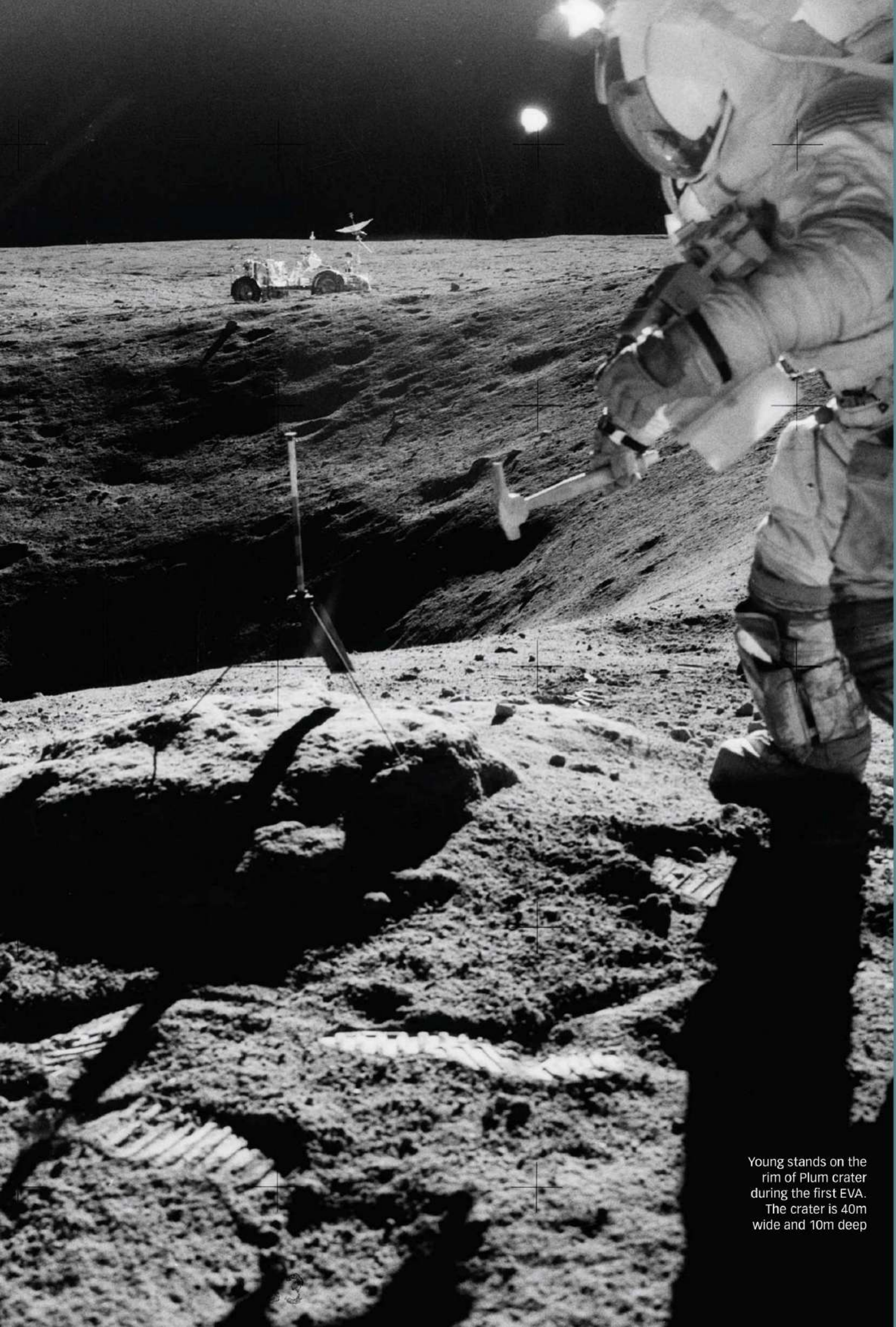
BACKUP CREW
LUNAR MODULE PILOT
Edgar Mitchell

RIGHT Young inspects a large boulder during the third EVA in the Descartes Highlands

BELOW The mortar box containing four grenades ready to be deployed by remote control



RIGHT Young collects samples at the North Ray crater site – by Apollo 16, the astronauts were skilled geologists



Young stands on the rim of Plum crater during the first EVA. The crater is 40m wide and 10m deep

MISSION TIMELINE

16 APRIL 1972
After an uneventful countdown, Apollo 16's huge Saturn V rocket ignites and lifts off at 17:54 GMT, beginning a flawless ascent to Earth orbit.

16 APRIL: 2 HOURS, 33 MINUTES
The Saturn IVB upper stage ignites for a second time, pushing Apollo 16 out of Earth orbit and towards the Moon.

19 APRIL: 74 HOURS, 34 MINUTES
The docked vehicles of Apollo 16 enter lunar orbit after a braking engine burn from Casper.

20 APRIL: 96 HOURS, 13 MINUTES
Lunar Module Orion undocks from Command Module Casper for a visual inspection prior to descent to the Moon.

20 APRIL: 97 HOURS, 40 MINUTES
Mattingly reports a problem with Casper's engine steering system: "I be a sorry bird," he tells Mission Control. The landing descent is put on hold.

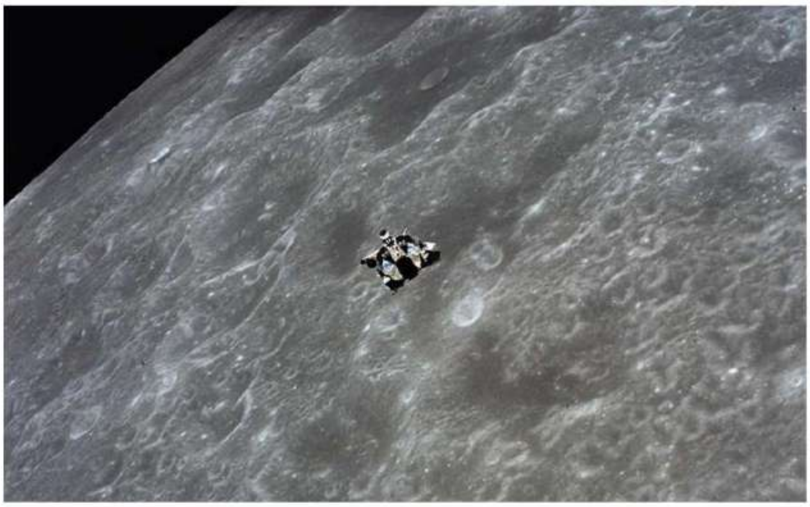
21 APRIL: 104 HOURS, 29 MINUTES
After a tense few hours, the landing goes ahead and Orion touches down.

21 APRIL: 118 HOURS, 53 MINUTES
The first of the three lunar surface EVAs begins and the Lunar Roving Vehicle has its first outing. Young and Duke set up science experiments. The astronauts would gather 95.8kg of lunar samples in total.

24 APRIL: 175 HOURS, 31 MINUTES
Orion's ascent stage blasts off from the Moon and heads for a rendezvous with Casper, waiting in orbit overhead.

25 APRIL: 218 HOURS, 39 MINUTES
On the trip back to Earth, Mattingly goes on a spacewalk to remove the film canisters from Casper's lunar surveying equipment.

27 APRIL: 265 HOURS, 51 MINUTES
Casper splashes into the Pacific Ocean and is picked up by USS *Ticonderoga*. The CM is taken to North Island Naval Air Station in San Diego.



As seen from Casper, Lunar Module Orion ascends from the Moon for rendezvous with the mother ship

> "I like an occasional orange, I really do. But I'll be damned if I'm gonna be buried in them"

▶▶ A mortar box with four rocket-propelled grenades was also deployed to cause more powerful shocks. Each grenade was primed to travel a different distance, ranging from 150m to 1.5km, and explode when it hit the ground. Three were triggered by radio control a month after Apollo 16's departure, but the fourth launch was cancelled after the third grenade upset the mortar.

Orange alert

On the lunar surface, Duke had a problem with orange juice. Medics had urged both astronauts to top up their potassium levels by drinking it regularly from a tube dispenser inside their helmets, and a leak soaked Duke's suit. He even got the drink in his hair. Young complained: "I like an occasional orange, I really do. But I'll be damned if I'm gonna be buried in them," as well as some choice expletives. Mission Control reminded Orion's crew that their microphones were open.

During their lunar visit, the two men drove 27km in three EVAs. Their take-off and redocking with Casper was successful, although various glitches kept everyone alert. As Apollo 16 headed back to Earth, Mattingly carried out a spacewalk to retrieve several film canisters from the side of the Service Module.

Splashdown was on 27 April 1972. The aircraft carrier USS *Ticonderoga* took the CM to North Island Naval Air Station in San Diego, California, where Casper had one last, nasty surprise up its sleeve.

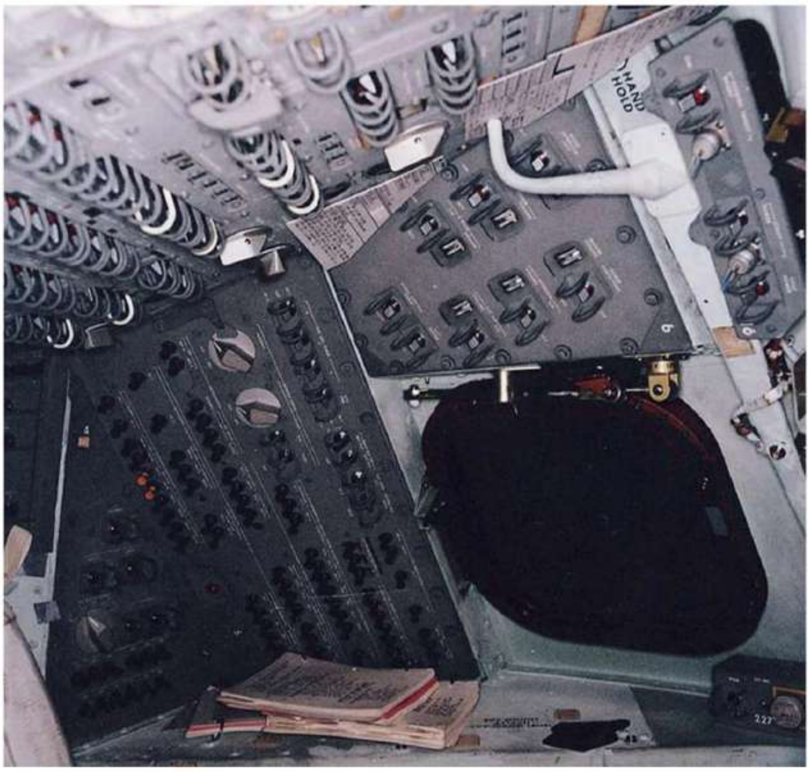
An explosive return

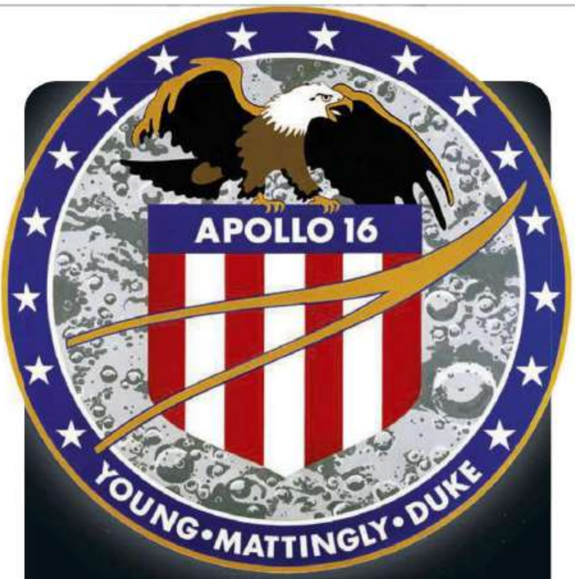
During Apollo 15's landing, some of the parachute harness lines had been scorched by corrosive fuels dumped from the thruster system, so Apollo 16 was ordered not to vent any leftover fuel during re-entry. The landing was successful. However, over a week later, on 7 May, the noxious residues were being drawn off into tanks on a cart. Somehow the cart became overpressurised and it exploded, exposing 46 technicians to toxic fumes and fracturing one man's kneecap. Fortunately, no lasting damage was done to the ground crew.

The highlands also tripped up NASA geologists, because the astronauts didn't see much evidence of the volcanic rocks everyone had been expecting. "There you are, our mysterious and unknown Descartes Highland plains. Apollo 16 is gonna change your image," Young had said when excitedly first setting foot on the lunar surface – and the mission undoubtedly did that. For Apollo 16, the Moon was as full of surprises as CM Casper had been.

ABOVE King crater, located on the far side of the Moon, is 76km wide

RIGHT Orion shortly before it redocks with Casper to return to Earth





MISSION BADGE

The crew of Apollo 16 wanted three elements to be included in their patch: patriotism, teamwork and their destination, the Moon. The 16 white stars in the border represent outer space and the flight number, while the 'wish bone' across the centre is NASA's symbol of flight. The shield motif only appears on this patch and Apollo 10's – John Young was a crew member on both flights.

ABOVE Back on Earth: Young and Mattingly relax in the recovery raft

LEFT Inside Casper: even after the mission's end, the Command Module caused problems

Flames from the five engines of the Saturn V's first stage light up the night

7 December 1972

APOLLO 17

THE LAST MANNED MOON MISSION STILL HAS A GREAT MANY FIRSTS

MISSION FACTS

OBJECTIVE: To land in the Taurus–Littrow area where it was hoped the crew would find rocks both older and younger than those that had previously been returned.

DURATION: 12 days, 13 hours, 51 minutes, 59 seconds

LUNAR SURFACE TIME: 3 days, 2 hours, 59 minutes, 39 seconds

COMMAND MODULE: America

LUNAR MODULE: Challenger

The Florida night sky glows orange as Apollo 17 blasts off into space

When NASA conceived Apollo in 1960, it was against a backdrop of intense political passions. The Cold War was in its ascendancy, and the USA and the USSR were locked in the battle of wills we know today as the Space Race. Originally, 20 missions were planned for the Apollo programme, but with Neil Armstrong's first steps all but securing victory in the Space Race, NASA was soon under pressure to cut its spending.

Apollo 20 was the first victim, cancelled in January 1970. Apollo 18 and 19 were culled in September of the same year, and NASA subsequently re-planned the remaining flights. Apollo 17, originally destined for the Marius Hills in the Oceanus Procellarum, was now bound for Taurus–Littrow, a lunar valley on the edge of the Mare Serenitatis. The landing site had shown promising signs of recent volcanic activity when Apollo 15 imaged it in 1971.

But although Apollo 17 was the final mission, it was still a mission of firsts. It was the first manned night launch from the Kennedy Space Center, though that didn't stop an estimated half a million people gathering to watch, including, for the first time, Patrick Moore. Another first was the inclusion of a trained scientist on the crew roster – Lunar Module (LM) pilot Harrison Schmitt. Originally scheduled for Apollo 18, he was bumped up when the later mission was cancelled. With a PhD in geology, Schmitt was able to provide a much more detailed commentary of the surface of the Moon.

> “With Neil Armstrong's first steps all but securing victory in the Space Race, NASA was soon under pressure to cut spending”

Minor technical issues delayed the launch of Apollo 17 – carrying mission commander Eugene Cernan, Command Module (CM) pilot Ron Evans and Schmitt – by two hours and 40 minutes, but lift-off finally happened at 00.33 EST (05:33 GMT). Following a perfect ascent, the third stage fired again to increase the highest point of their orbit to match the distance to the Moon. The CM America and ▶▶

MEET THE CREW

COMMANDER

EUGENE CERNAN

Cernan was born on 14 March 1934 in Chicago and studied aeronautical engineering while at the Naval Postgraduate School, joining NASA in October 1963. He flew on Gemini 9A and travelled on Apollo 10, coming within 15,250m of the lunar surface. Cernan left NASA in 1976 and died on 16 January 2017, aged 82.

BACKUP CREW
COMMANDER
John Young

COMMAND MODULE PILOT

RONALD EVANS

Born on 10 November 1933 in Kansas, Evans also studied aeronautical engineering at the Naval Postgraduate School. He joined NASA in 1966. Apollo 17 was his only space flight, although he also served as the backup Command Module pilot on Apollo 14. He left NASA in 1977 to work in industry. Evans died of a heart attack on 7 April 1990, aged 56.

BACKUP CREW
COMMAND MODULE PILOT
Stuart Roosa

LUNAR MODULE PILOT

HARRISON SCHMITT

Hailing from Santa Rita, New Mexico, Schmitt was born on 3 July 1935. Before becoming a pilot, the first scientist astronaut to fly on a NASA mission had helped to design the geological training for the early Apollo missions. Schmitt left NASA in 1975 and was the Republican senator for New Mexico from 1977 to 1983.

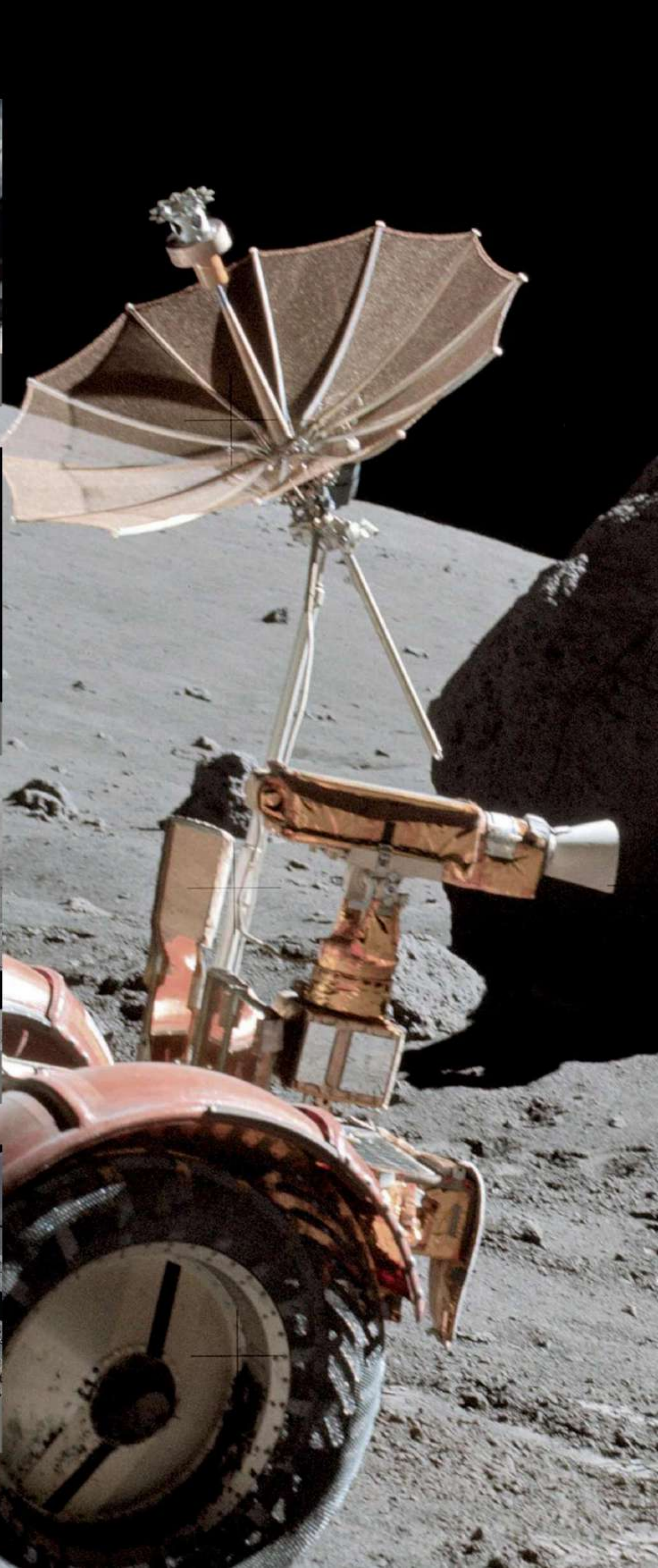
BACKUP CREW
LUNAR MODULE PILOT
Charles Duke

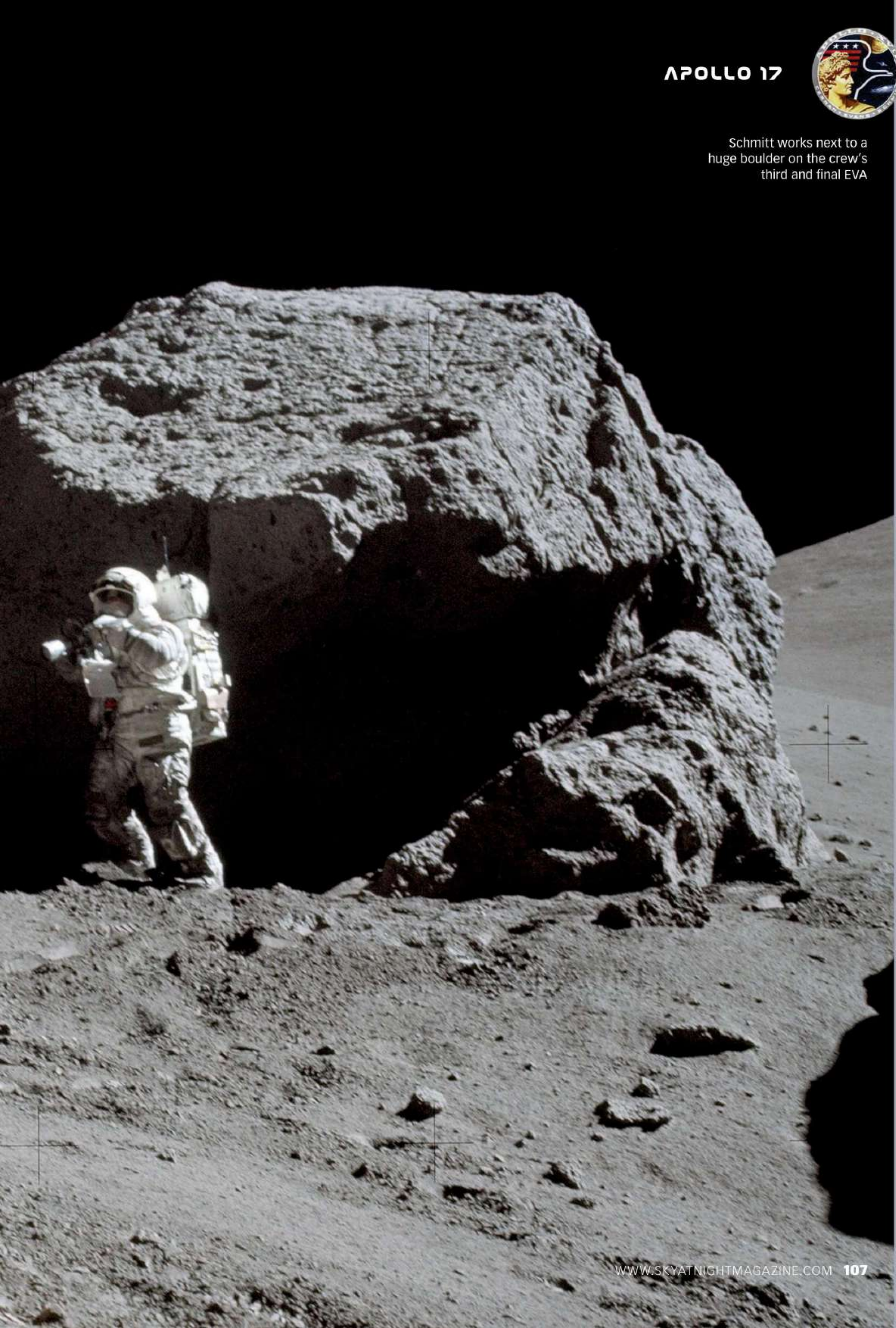
Schmitt took this image of his crewmates experiencing zero gravity aboard America

The tiny dot in the centre of this photo is the LM coming in to land, as seen from the CM

Cernan takes the lunar rover for a test drive before loading it up with equipment

The orange soil that Schmitt discovered at Shorty crater during their second EVA





Schmitt works next to a huge boulder on the crew's third and final EVA

MISSION TIMELINE

7 DECEMBER 1972
The final mission in the Apollo programme lifts off at 05:33 GMT (00:33 EST). Even though it is the first night launch, approximately 500,000 people turn out to witness it.

---

7 DECEMBER: 3 HOURS, 12 MINUTES
The S-IVB stage fires for 351 seconds, sending the mission Moonwards.

10 DECEMBER: 86 HOURS, 14 MINUTES
The CSM's engine fires for 393 seconds to reduce speed, allowing the craft to be captured by the Moon's gravity.

11 DECEMBER: 110 HOURS, 21 MINUTES
The crew lands on the lunar surface on target with two minutes of propellant remaining.

11 DECEMBER: 114 HOURS, 21 MINUTES
Cernan steps off the ladder onto the lunar surface.

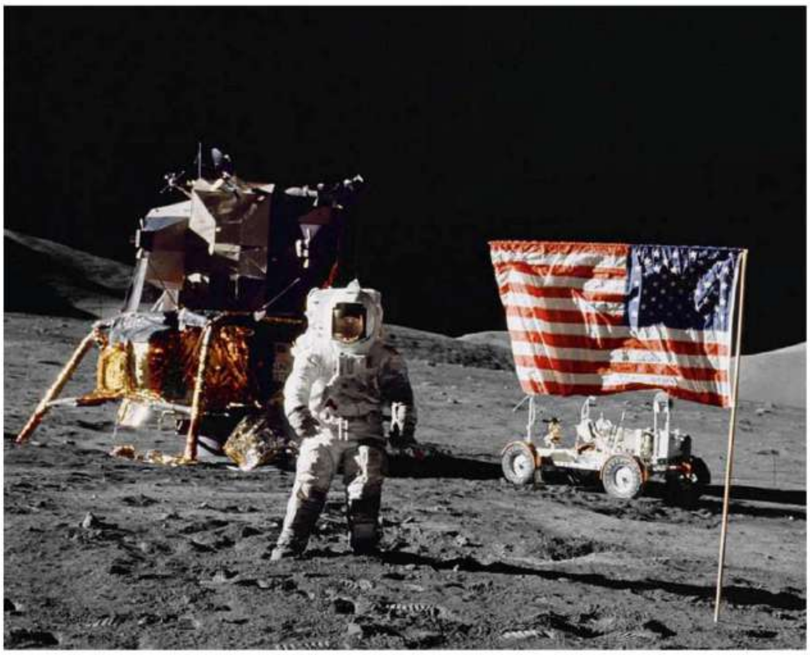
14 DECEMBER: 168 HOURS, 7 MINUTES
Final entry into the lunar module. Cernan becomes the last man to walk on the Moon. In total, Cernan and Schmitt covered 35.75km and returned with around 110kg of samples.

14 DECEMBER: 185 HOURS, 21 MINUTES
Lift off from the Moon. The launch is captured by the lunar rover's camera.

15 DECEMBER: 191 HOURS, 18 MINUTES
The ascent stage of the Lunar Module is jettisoned and its engine is fired to crash it into the Moon. This provides data for the seismometers left at the Apollo landing sites.

17 DECEMBER: 254 HOURS, 54 MINUTES
Evans leaves the Command Module to conduct a spacewalk and retrieve film from the scientific instrument bay.

19 DECEMBER: 301 HOURS, 51 MINUTES
Splashdown in the Pacific Ocean, 6.4km from the recovery ship USS *Ticonderoga*.



Schmitt stands next to the flag of the USA. In the background are Lunar Module Challenger and the Lunar Roving Vehicle

> “We leave as we came and, God willing, as we shall return, with peace and hope for all mankind”

▶▶ LM Challenger undocked from their spent rocket and coasted on.

Tight landing

Apollo 17 entered lunar orbit some 86 hours after launch. The launch delay had been countered by a faster than expected trip to the Moon – a good thing, as the angle of the Sun would help Cernan and Schmitt watch for obstacles as they landed.

The landing was tricky: the typical touchdown target zones for Moon landings had been 3km by 2km, but to safely land in Taurus–Littrow that had to be reduced to a 1km circle.

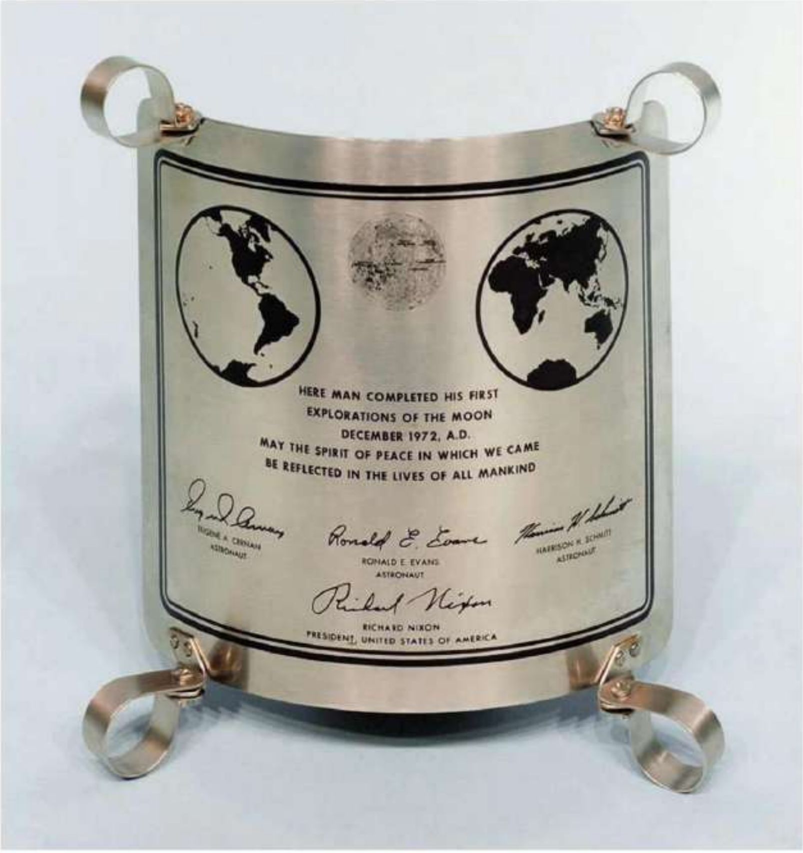
Cernan brought Challenger down on a flat spot well within the target area. In common with the previous crews, both Schmitt and Cernan had trouble estimating distances and sizes without familiar visual cues.

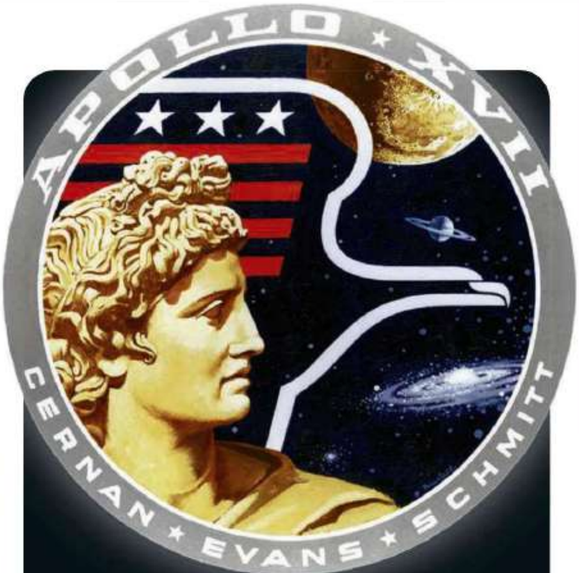
Only four hours after landing, Cernan was ready to step off the ladder. He dedicated his first step on the Moon to “all those who made it possible”. Schmitt quickly joined him on the surface and almost at once started a running commentary on the types of rock he could see close by. With the most distant objective for the first moonwalk only 2km away, the pair started their work close to the LM. The lunar rover proved easy to deploy – although the crew later had to make a repair to it with duct tape – and setting up the scientific station also went smoothly. Challenger's crew was ready to explore further afield.

The high work rate that had been set in the first moonwalk was repeated on a further two journeys out in the LRV. During the second outing, at crater Shorty, Schmitt caused a stir among the scientists on Earth when he found an orange deposit. Was this evidence of recent lunar activity? When analysed back on Earth, the data showed that this area of the Moon had indeed been volcanically active, but it was far from recent, dating from approximately 3.64 billion years ago.

As Cernan paused, taking a last look before climbing into the LM for the final time, he said: “As we leave the Moon at Taurus–Littrow, we leave as we came and, God willing, as we shall return, with peace and hope for all mankind.”

And with that, our presence on the Moon came to an end – for now.


HERE MAN COMPLETED HIS FIRST
EXPLORATIONS OF THE MOON
DECEMBER 1972, A.D.
MAY THE SPIRIT OF PEACE IN WHICH WE CAME
BE REFLECTED IN THE LIVES OF ALL MANKIND
EUGENE A. CERNAN
ASTRONAUT
RONALD E. EVANS
ASTRONAUT
HARRISON H. SCHMITT
ASTRONAUT
RICHARD NIXON
PRESIDENT, UNITED STATES OF AMERICA


APOLLO ★ XVII
CERNAN ★ EVANS ★ SCHMITT

MISSION BADGE

NASA wanted the final Apollo mission badge to signify the success of the programme, with a contemporary eagle overlaying the Moon to show that "man has visited and in a sense conquered". The face on the patch is taken from the famous marble statue of Apollo, on display at the Vatican Gallery in Rome.

ABOVE The plaque left at the landing site by Cernan and Schmitt

RIGHT Command Module America during rendezvous with the Lunar Module

ABOVE The returned crew greet their families at Ellington Air Force Base, Texas

LEFT One of the samples brought back from the Moon. The rock weighs 461g and is 10cm long

BBC
Sky at Night
MAGAZINE

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BBC
Sky at Night
MAGAZINE

TIMELINE

The race from the Earth to the Moon took a number of twists and turns along the way

EARLY 1950S · 1957 · 1958 · 1959 · 1960 · 1961 · 1962 · 1963 · 1964 · 1965

EARLY 1950s
Tensions between the Soviet Union and the United States reach their peak, with intense competition both politically and technically.

OCTOBER 1957
The Soviet Union kick-starts the Space Race with the launch of its first satellite, Sputnik I. The 96-minute orbit around Earth has the world gripped, sparking the public's infatuation with space travel. The American government is rocked.

NOVEMBER 1957
The follow up to Sputnik I is the Soviet's Sputnik II, which has a crucial passenger on board: Laika the dog. Although she dies after a few hours due to overheating and stress, the trip gives scientists vital information about how living creatures respond to being in space.

FEBRUARY 1958
▲ The USA launches its first satellite, Explorer 1.

DECEMBER 1958
▼ The United States rejoins the race with the Mercury programme, their first attempt at human spaceflight. To reach its goals they have to be the first nation to send a man into orbit around Earth.

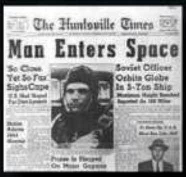
MAY 1959
The US wins the race to send animals into space and get them back alive. Able and Baker become world-famous space monkeys – and live to tell the tale.

OCTOBER 1959
The Soviet Union launches Luna 3 – a satellite that takes the first photo of the far side of the Moon.

The USA increases its spending on nuclear missiles.

NOVEMBER 1960
▼ John F Kennedy is elected President of the United States.

APRIL 1961
▼ Yuri Gagarin is an instant celebrity when he becomes the first human to go into space. The Soviet Union sends him into orbit for 108 history-making minutes, sending the message it won't be easily defeated.



The Huntsville Times

Man Enters Space

So Close Yet So Far Sights Cape

Soviet Officer Orbits Globe In 5-Ton Ship

MAY 1961
▲ Three weeks after Yuri Gagarin's historic space flight, Alan Shepard becomes the second man in space, flying in the Mercury programme's Friendship 7 spacecraft.

MAY 1961
President Kennedy sends a clear message to the world when, in a speech to Congress, he commits the US to sending a man to the Moon and returning him safely to Earth before the decade is out.

MAY 1961
Competition heats up with the announcement of the Mercury programme's successor: Project Apollo. The main objective is to land a man on the Moon before the Soviet Union.

OCTOBER 1961
The Soviets do nothing to quash America's fear by testing 'Tsar Bomba' – the most powerful nuclear weapon ever detonated.

JANUARY 1962
NASA launches the Gemini Project to act as a 'helping hand' for Apollo. Its aim is to develop the technology needed to reach the Moon.

FEBRUARY 1962
▼ The Mercury programme makes headlines by sending the first American, John Glen, into orbit.

Friendship 7

OCTOBER 1962
The USSR is seen setting up nuclear missiles in Cuba. This does nothing for the confidence of the US, behind in both the space and arms races.

JULY 1963
The US launches Syncom 2, the first communications satellite, which allows JFK to make a phone call to the Nigerian prime minister.

NOVEMBER 1963
The world mourns when President Kennedy is assassinated. He is succeeded by Lyndon B Johnson.

OCTOBER 1964
The Soviets launch Voskhod 1, the first spacecraft to carry more than one crewman.

MARCH 1965
Gus Grissom and John Young keep the Soviet Union on their toes as they fly the first manned Gemini mission.

JUNE 1965
Three months after Russia's Alexei Leonov, Ed White makes America's first spacewalk.

FEBRUARY 1966

The Soviet Union pulls ahead in the Space Race and lands Luna 9, an unmanned spacecraft, on the Moon. At the same time, NASA finishes developing its Saturn IB rocket.

NOVEMBER 1966

NASA introduces underwater training to simulate weightlessness. It helps the final Gemini crew prepare to work outside the spacecraft.

NOVEMBER 1966

The pressure rises at NASA and, fearing it will lose the race for power and prestige, the full lunar mission is brought forward.

JANUARY 1968

▼ Apollo 5 is severely delayed due to problems developing the Lunar Module. However, the unmanned mission is considered a success.

APRIL 1968

Apollo 6 marks the last unmanned mission and the beginning of America's final stretch to land a man on the Moon.

SEPTEMBER 1968

Zond 5 is the USSR's comeback. The first unmanned spacecraft to orbit the Moon adds to the pressure on NASA.

OCTOBER 1968

NASA builds confidence with Apollo 7, the first manned flight in Earth orbit since the Apollo 1 tragedy. It is a success.

DECEMBER 1968

Apollo 8 causes great excitement around the world by televising a reading from the Bible on Christmas Eve as it orbits the Moon.

▲ Public interest in the space programme takes a nosedive after Apollo 11. General feeling is that the spending is unnecessary as the Moon has been reached.

JANUARY 1970

▼ NASA announces the cancellation of its planned Apollo 20 flight, giving the biggest indication that it is feeling the reduction in enthusiasm after the Moon landing.

JANUARY 1971

The Apollo 14 crew enjoys some sport in space, with Alan Shepard hitting two golf balls off the Moon's surface.

APRIL 1971

The Soviet Union launches the first space station – Salyut 1.

JULY 1971

The 'most successful lunar visit ever' comes in the form of Apollo 15, but whisperings of a reduced budget are getting louder.

APRIL 1972

Apollo 16 is the penultimate mission for Project Apollo – but they make the most of it, spending almost three days on the Moon.

DECEMBER 1972

Apollo 17 is the last mission to fly, as public support wanes and NASA's funding is cut.

MAY 1973

The USA launches Skylab, its first space station.

JULY 1975

▲ The Apollo–Soyuz Test Project brings together the two biggest rivals in space travel. It marks the end of the Space Race, with the USA being the clear winners.

1966 · 1967 · 1968 · 1969 · EARLY 1970S · 1970 · 1971 · 1972 · 1973 · 1975

JANUARY 1967

▼ A cabin fire breaks out during a launch pad test for Apollo 1, killing all three crewmembers.

NOVEMBER 1967

Apollo 4 highlights technological advances when the US unveils its impressive Saturn V rocket.

JANUARY 1969

Richard Nixon becomes President of the USA.

MARCH 1969

The US pulls ahead in the race as Apollo 9 carries out the first crewed flight of a lunar module.

MAY 1969

Apollo 10 is the unofficial dress rehearsal for the Moon landing. There's a feeling in the air that America is about to win the race.

JULY 1969

▲ JFK's dream to get a man on the Moon is finally realised when Apollo 11 touches down in the Sea of Tranquility on 20 July 1969. The televised event is watched by over 600 million people worldwide.

NOVEMBER 1969

Apollo 12 lands on the Moon, but public interest is dwindling. The accidental destruction of the colour TV camera means the public can't watch.

FEBRUARY 1970

The excitement of the Moon landing seems lightyears away as protests break out in the USA against the ongoing Vietnam War.

APRIL 1970

▲ Apollo 13 is deemed a successful failure after an explosion causes the mission to be aborted – the near loss of the astronauts furthers the anti-NASA feeling.

JULY 1975

The Apollo–Soyuz programme uses the spacecraft developed for Apollo 18. The irony isn't lost on an American public, who feel the money used to beat the USSR has been wasted on what is now a joint venture.

Remembering

NEIL ARMSTRONG

In one of the last pieces he wrote, Sir Patrick Moore paid tribute to the first person on the Moon. Both space pioneers passed away in 2012

If one wanted to select a suitable candidate for the first man on the Moon, surely one should look no further than Neil Armstrong. I feel that I have been particularly privileged to have been involved in a very minor capacity and to have come to know him well, both before and after his lunar trip. Neil lived to be 82 years old, passing away on Saturday 25 August 2012 following complications from heart bypass surgery.

Quiet confidence

Neil was, in his private life, a rather shy man and always credited others rather than himself. On meeting him, one was conscious of a quiet confidence that he would be able to tackle any crisis – and this was true. I was privileged to interview him on his return to Earth. Several interviews followed, but after that he kept very much out of the limelight.

He had been a fighter pilot in the Korean War before becoming an astronaut, and was a teacher after. He believed in passing on his knowledge to others and for most of his post-Apollo career he taught as a professor at the University of Cincinnati. He disliked giving interviews and in this he differed from fellow Apollo 11 astronaut Buzz Aldrin, who was, in the best sense of the word, a publicist.

Having had the chance to talk to both the Apollo 11 pioneers, I am in a good position to write about Neil and, I hope, to address some of the rumours that in my view could be injurious.

Armstrong aboard the Lunar Module as it rests on the Moon's surface

> “Neil was, in his private life, a rather shy man and always credited others rather than himself”

Neil Armstrong and Buzz Aldrin were chosen to be the first two men on the Moon, and there has been discussion as to how the ‘first down’ was selected. It is perfectly true that when we talk about the first man on the Moon, all the attention is given to Neil and comparatively little to Buzz. Buzz is rumoured to have resented this: claims that were said to be backed up by the fact that the first photographs from the Moon are mainly of Buzz. In my view there is a perfectly simple explanation for this: Neil was the main cameraman for the mission and obviously would find it difficult to take photos of himself.

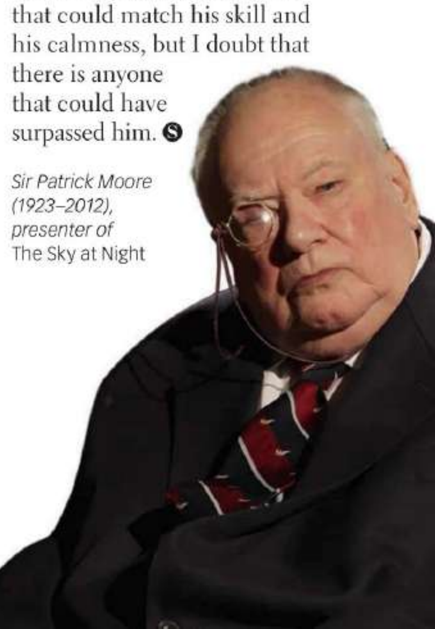
Remember, space travel is still a very dangerous business and in the case of the first Moon landing, there were many more uncertainties than before or since. Of course, we had mapped the Moon exhaustively and the old theory that the lunar maria were coated with soft, treacherous dust had been disposed of. But only a few years earlier, a leading scientist had claimed that any vehicle landing on the Moon would sink into the soft dust. If this had been correct, lunar travel would have been virtually impossible.

No one really knew how firm the surface would be. Furthermore, if the spacecraft landed in an area where there was an unforeseen depression and came down at an angle, it would not have been possible to take off again and return to orbit. Neil and Buzz showed the way, and others who followed them knew what to expect and what not to expect.

Another of Neil's virtues in this kind of venture was his quick-wittedness. When Apollo 11 came down on the Sea of Tranquility, they had only a few seconds of fuel left and just the one chance of making a successful landing. If they had not taken it and had instead blasted back into orbit there would be another ‘first man on the Moon’.

I must stress that the decision to go ahead with the landing, in spite of the fact that things were not quite as they should be, was Neil's decision and his alone. His opinion was vindicated and I think the whole world sighed with relief when he announced: “The Eagle has landed.”

In every way, Neil Armstrong was an ideal person to make the first manned landing. There may have been others that could match his skill and his calmness, but I doubt that there is anyone that could have surpassed him.



Sir Patrick Moore (1923–2012), presenter of The Sky at Night

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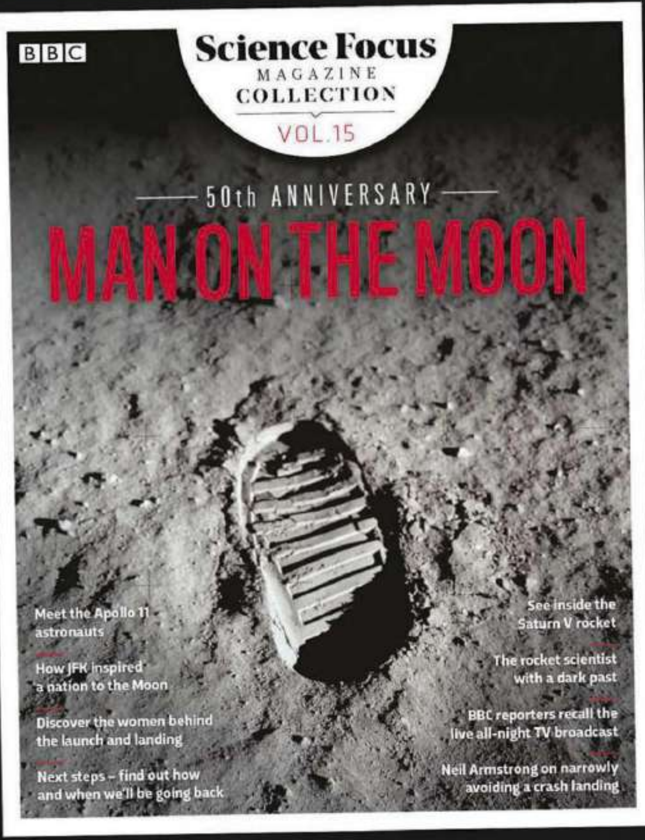
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Discover the women behind the launch and landing

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- Neil Armstrong on his emergency lunar landing
- The women who were key to Apollo 11's success
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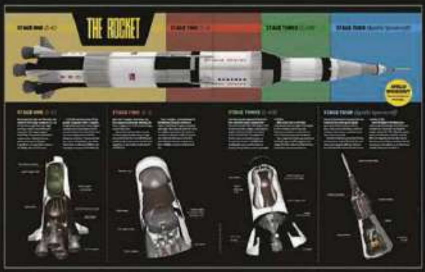
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Gene Cernan, last man on the Moon